Report of the Chief of the Bureau of Entomology and Plant Quarantine

1953

UNITED STATES DEPARTMENT OF AGRICULTURE

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Report of the Chief of the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, 1953

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 1, 1953.

DR. B. T. SHAW,
Agricultural Research Administration.

DEAR DR. SHAW: Realinement of several important phases of entomological research was accomplished during the past year. There were also major accomplishments in plant quarantine and insect control activities. These activities are summarized in the attached report for the fiscal year ended June 30, 1953.

Sincerely yours,

AVERY S. HOYT,
Chief.

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THIS YEAR IN BRIEF

Two popularly accepted items were among this year's Bureau contributions. Insects, the Yearbook of Agriculture, 1952, for which Bureau personnel had major responsibility for text and illustrations, was chosen by the Textbook Clinic of the American Institute of Graphic Arts as one of the outstanding textbooks of the year, in addition to its inclusion in the 1953 list of the Fifty Books of the Year selected on the basis of book design by the Trade Book Clinic. EQ–53, a formula that mothproofs washable woolens by merely adding a few spoonfuls of an emulsifiable concentrate to the wash or rinse water, was widely publicized and many manufacturers are now formulating it for retail sale.

Comprehensive plans were made during the year for a concentrated attack on the pink bollworm, the most destructive of cotton pests. For the first time in its 36 years' existence in the Southwest, this pest has caused extensive commercial damage in southern Texas.

Possibly the most destructive bark bettle epidemic ever experienced is developing in the Douglas-fir forests of western Oregon. Before it is controlled or runs its natural course the beetle is expected to kill upwards of 5 billion board feet of timber. Insects rank close to the top among destructive agencies in our forests. During the last 10 years they have been especially severe. For example, more than 4 billion board feet of Engelmann spruce were killed in a single epidemic of a bark beetle in Colorado. In Oregon and Washington more than 2¾ million acres of fir forest have been sprayed by airplanes to prevent wholesale killing of valuable trees by the spruce budworm.

Corn insect research was realined to place more emphasis on the control of all major corn pests and to mesh Bureau projects with similar research by the States and other agencies. Previous work has been largely concentrated on methods of controlling the European corn borer and the corn earworm.

All Bureau research involving the application of techniques of atomic science to insect investigations is being coordinated by a Radioisotope Committee. In addition to supervising the use of radioactive materials, the Radioisotope Committee will suggest further uses that may be made of such materials. Three Bureau scientists, two entomologists and a chemist, have completed a training course at the Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn., to learn how radioisotopes may be utilized in entomological research. Previous Bureau research employing radioactive insects and materials is being extended to study how an insecticide kills an insect, the translocation of systemic insecticides, factors in insect resistance to insecticides, the distance and speed of insect migration, the abundance of insects, bee feeding habits, and the spread of bee diseases.

Invented and patented for public use 12 years ago by Bureau scientists, the aerosol, or mist-spray, dispenser has become practically the basis of a $95 million industry in this country. It is now being used for dispensing deodorants, shaving cream, whipped cream, and numerous other materials.

Expansion of insecticide-manufacturing facilities in 1951 and 1952 resulted in plentiful supplies of the new synthetic organic insecticides during the 1952 crop season. Drought over much of the country in 1952 resulted in a lower consumption of insecticides than in previous years. Consequently there was a large carryover of many of the important insecticides, which should assure an ample supply for use throughout 1953. It has been estimated by a national trade association that pesticide manufacturers are now producing more than 1 billion pounds of finished insecticides per year with a value of more than $250 million.

Nineteen entomologists were engaged in the Point IV technical-assistance program at the end of the fiscal year. These men were stationed in 12 countries in the Eastern and Western Hemispheres. The major Point IV activity in which this Bureau collaborated was the Regional Locust Control Program, conducted in cooperation with the Foreign Agricultural Service of the United States Department of Agriculture and the Foreign Operations Administration in Iran, Pakistan, India, Iraq, Jordan, and Ethiopia. Assistance was rendered in these countries through demonstration of aerial spraying techniques and training of pilots, mechanics, and locust-control personnel. Bureau services provided to Point IV entomologists included insect identification, program planning, general advice, and guidance on entomological problems in foreign countries.

Numerous phases of the Bureau's activities were reviewed by Bureau specialists with 827 foreign visitors who were in the United States during 1952 under the sponsorship of the Department's Foreign Agricultural Service. An Agricultural Research Administration consultant on international programs accompanied these visitors and assisted them in making the appropriate contacts.

F. C. Bishopp, assistant chief in charge of entomological research, and Ralph A. Sheals, assistant chief in charge of administration, left their employment in the Bureau at the end of the fiscal year. Dr. Bishopp resigned, after nearly 50 years' service, to accept employment with the Oscar Johnston Cotton Foundation as coordinator of pink bollworm research. Mr. Sheals retired after 35 years of Federal employment. Edward F. Knipling, leader of the Division of Insects Affecting Man and Animals, was appointed to succeed Dr. Bishopp, and Henry G. Herrell, deputy assistant chief in charge of administration, succeeded Mr. Sheals, both appointments being effective July 1, 1953. A few weeks prior to Dr. Bishopp's resignation, he and E. Ralph Sasscer, leader of the Division of Plant Quarantines, were recipients of the Department's distinguished service award at an honor awards ceremony on May 19, 1953. Bureau personnel who received superior service awards were Carl H. Gaddis, Division of Stored Product Insect Investigations, Merton C. Lane and Marshall W. Stone, Division of Truck Crop and Garden Insect Investigations, and John M. Miller, Division of Forest Insect Investigations. A unit award was also made to the Bureau's fruit fly research laboratory in Honolulu.

K. P. Ewing, for 32 years a research entomologist with the Division of Cotton Insect Investigations, was designated on September 3, 1952, as coordinator of the expanded cooperative pink bollworm research programs. Subsequently Mr. Ewing was appointed leader of the Division of Insects Affecting Cotton and Other Fiber Plants, succeeding R. W. Harned, who had headed the Division since 1931. C. F. Rainwater was designated as assistant division leader. Mr. Harned will continue as a staff assistant to the Bureau Chief and as a consultant on cotton insects and their control. T. P. Cassidy has been assigned responsibility for research on insects affecting rubber and fiber plants other than cotton.

David G. Hall, acting in charge of the Division of Information, became head of that division October 23, 1952.

The former Division of Grasshopper Control was reestablished as a project under the general direction of the Regional Director at Minneapolis, Minn., effective July 28, 1952. James R. Dutton, formerly assistant division leader, was designated as project leader, and Arling Gardner as assistant project leader. Headquarters for this activity will continue at Denver, Colo.

Historical records have been consulted to obtain interesting entomological information that may be presented in 1954 during the centenary celebration of professional entomology. Elaborate plans for recognizing this commemoration have been made by committees appointed for that purpose in the Bureau, profession, and industry.

The Chief of the Bureau had an opportunity briefly to explain some of the Bureau's outstanding accomplishments during the visit of President Eisenhower to the Agricultural Research Center at Beltsville on May 26, 1953.

STORED-PRODUCT INSECTS

Formula EQ–53 To Protect Washable Woolens Announced

A formula for a nonionic emulsifiable DDT concentrate which can be used in the home and in commercial laundries to mothproof washable woolens was released to insecticide manufacturers in December 1952 so that the preparation would be available on the retail market in 1953. The emulsion is added direct to wash or rinse water at the rate of 1 tablespoonful per pound of woolens, and the resulting deposit in the cloth will protect it from insect damage in storage for a year or more. Extensive research had revealed that from very dilute nonionic emulsions woolen fabrics pick up considerably more DDT than would be expected. It was also found that the amount of pickup was determined by the proportion of DDT to the wool, and was not regulated by the concentration of DDT in the water bath.

Cool Storage Effective Against the Cigarette Beetle

All stages of the cigarette beetle were killed by long exposure to storage conditions of 47° to 48° F. and 68 percent relative humidity. Eggs were killed within 13 days. A few larvae required 88 days but most were dead after 14 days. One adult emerged from a pupa held 109 days. Very few adults survived 60 days' exposure although a few lived up to 89 days. Cool storage is used by some tobacco manufac-

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turers for preventing fermentation or "sweating" and, also, insect damage.

Nonexplosive Aerosol Formulation Developed

A formulation for use in industrial aerosol generators, to be applied in warehouses for control of stored-product insects, has been developed and thoroughly tested under practical conditions. It contains 10 percent of DDT, 2 percent of lindane, 5 percent of S. A. E. 50 motor oil, and 83 percent of tetrachloroethylene. It is applied at the rate of 2 quarts per 100,000 cubic feet every 2 weeks for the first four applications and monthly thereafter. This material is not for use where food products are exposed. Operators have been cautioned to apply this aerosol from outside the building and not to expose themselves unless wearing a mask and protective clothing. Four periodic applications of this aerosol produced an effective residue on horizontal surfaces.

Flammability of Oils and Solvents Used in Aerosol Formulations Determined

Basic data were developed on the flammability of the various solvents or oils that are commonly contained in aerosol formulations used in thermal or mechanical generators. A test procedure recently standardized by the Chemical Specialties Manufacturers Association was used wherein the aerosol is sprayed into a drum containing an open flame. A swinging cover permits a nonhazardous explosion to take place when a flammable concentration is reached. The flammable concentration of 11 solvents and oils was determined individually when they were applied as coarse and as fine aerosols. The results showed that flammable concentrations of the individual materials ranged from about 18 to 60 times their concentration in aerosols as normally applied. This type of information had not been previously available from fire underwriters or the Bureau of Mines.

Effectiveness of Lindane Against Stored-Tobacco Insects Studied

Laboratory and tobacco warehouse tests have been continued in cooperation with tobacco manufacturers to determine the possibilities of using lindane sprays or aerosols for the control of the tobacco moth and the cigarette beetle. Both mist sprays and aerosols were effective against the tobacco moth, but neither form of application gave more satisfactory control of the cigarette beetle under warehouse conditions than does the standard pyrethrum spray now in general use. No effect could be detected on the smoking quality of tobacco exposed to lindane sprays or aerosols.

Insecticide Residues Protect Fibers and Fabrics for Long Periods

Hair and wool felts are still free from insect attack 4 years after applications of 2-percent DDT solutions or emulsions. Casein yarns are still protected 4 years after treatment with a 1-percent emulsion. Spanish moss and tow were protected 2 years, and feathers and down for 3 years by a 1-percent emulsion. Military uniforms made of DDT-treated cloth resisted insect damage after 4 years of continuous

exposure to a heavy insect population. Uniform cloth was completely protected under similar conditions for 5 years. DDT–treated bags have protected raw wool stored in them for more than 18 months. Lindane, chlordane, and dieldrin are also giving long time protection in comparable tests.

Method Developed for Forced Circulation of Fumigant in Loaded Grain Cars

A method of providing forced circulation in the fumigation of loaded freight cars of shelled corn or grain sorghum was developed over the last two years in cooperative tests with the Western Plant Board. The first season's tests demonstrated that forced circulation was necessary to get effective distribution of the fumigant through the load mass. In the past year further studies developed a probe duct system that can be installed in loaded cars in a half hour or less. Air is drawn from the floor level through the perforated tips of the probes by a portable blower outside of the car, and returned to the space above the load to complete the cycle. When the fumigant is added to the air stream it is drawn down through the load of grain. Changes in State quarantine regulations to require this procedure were recommended to the Uniform Quarantine Committee of the Western Plant Board and were adopted by the Committee.

Fortieth Ship Approved for Cold Treatment of Imported Fruit

The fortieth ship was approved during the year to cold-treat fruit in accordance with the provisions of the fruit and vegetable import regulations. The requirements are that fruit originating in countries quarantined because of fruit flies be held below certain temperature levels in refrigerated compartments for designated periods while in transit. Continuous records of the fruit temperatures taken on automatic recorders during the voyage are the basis upon which the shipment is cleared upon arrival. From February to June 1953, incoming shipments totaled 222,000 boxes of fruit from Argentina and 190,000 boxes from South Africa.

Electrical Apparatus Now Available To Determine Methyl Bromide Concentrations

A unit for analyzing gas concentrations by thermal conductivity has been calibrated for methyl bromide and tested in the field. This unit is portable and will give readings as a sample of gas is drawn through it. It has great potentialities as a research tool as well as a practical instrument for commercial fumigators. The manufacturer of the unit is putting out special instructions for its use for methyl bromide determination.

Approved Vacuum-Fumigation Facilities Rechecked

All vacuum-fumigation facilities in Atlantic coast ports approved for the treatment of commodities regulated by quarantines have been examined. Gas distribution was checked for each fumigation chamber by analyzing gas samples withdrawn from representative locations

during routine fumigations. Necessary modifications and changes to insure maximum efficiency have been made.

Promising New Methods Developed for Disinfesting Airplanes

Two new developments have occurred in research to improve the aerosol and residue spray treatments now used in airplanes to prevent accidental transmission of insect pests to new locales. One of them is a transparent residue with long-lasting qualities obtained by adding a chlorinated polyphenyl to lindane. The life of the lindane is extended appreciably, and the lindane stays in solution in the mixture, thus resulting in a clear and transparent residue. The second development is the use of lindane vapors in the plane. They are introduced by placing a filter screen impregnated with crystalline lindane in the air-conditioning duct. Each development was made by an entomologist-chemist research team. Their adaptation to use on military and commercial planes is being carried out cooperatively with the U. S. Air Force and the U. S. Public Health Service.

Light Traps Attractive to Stored-Grain Insects

Black-light traps have proved attractive to stored-grain insects in preliminary tests in Texas. A trap located in a grain sorghum bin at Beeville caught, during February 1953, 52,600 moths of four species, 14,252 rice weevils, 1,166 flour beetles, and smaller numbers of lesser grain borers and flat grain beetles. One trap in a rough-rice warehouse in Houston, where the insects were disturbed by removal of the rice, captured 43,700 insects in 18 hours. The results indicate that light traps may be useful in determining when control measures should be applied, and in evaluating the efficiency of such measures. These tests were made in cooperation with the Texas Agricultural Experiment Station and the Division of Farm Electrification of the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Rice Weevil Eats Five Times Its Own Weight

Rice weevils ate five times their own weight during development under laboratory conditions. Wheat kernels lost 20 percent of their original weight during the developmental period of rice weevils infesting them, and this loss was five times the weight of the emerged adults. Sixty-eight percent of the loss occurred during the first 28 days of development, during which there was no outward evidence of infestation. These data were collected in studies in which clean wheat was infested on a given date, and weighed at weekly intervals until development of the weevils was completed. Radiographs of the lots permitted determination of the exact number of kernels infested so that the mean weight loss per kernel could be computed.

COTTON INSECTS

Cotton Insects Cause Quarter-Billion-Dollar Loss

Cotton and cottonseed having an estimated value of $289,768,000 were destroyed in 1952 by insects, according to the National Cotton

Council. The council's estimate is based on final crop-production figures of the Bureau of Agricultural Economics. Similar estimates were $391,955,000 for 1951, and $907,884,000 for 1950. The council also estimated that during 1952 in the 16 major cotton-producing States the boll weevil, the pink bollworm, and other pests destroyed 927,000 bales of cotton and 574,300 tons of cottonseed.

One cooperative gin at Rio Hondo, Tex., reported that more than 10,000 bales were ginned there in 1951, but less than 2,000 bales were brought to the gin in 1952. Seventy-five percent of this reduction was attributed to insect damage. Three hundred members of the cooperative plowed under several hundred acres of cotton that had not been picked because of insect damage.

A farmer near Harlingen, Tex., said that he had never seen the pink bollworm as bad as it was in 1952, although he had been growing cotton all his life. He said some of his neighbors had practically their entire cotton crop destroyed by this insect. Some of the farmers who did pick their cotton got only 20 cents a pound, which was about two-thirds of the market value of undamaged cotton, because it was short staple and of low grade due to pink bollworm damage.

Pink Bollworm Research and Control Activities

Pink bollworm research activities greatly expanded

Pink bollworm investigations were greatly expanded during the year. Several new lines of investigation were tentatively set up, although work on some of them cannot be started until additional personnel and facilities are obtained.

Construction of a new pink bollworm research center was started during the fiscal year at Brownsville, Tex. The Texas Southmost College is building a $73,000, 25-room office-laboratory which the Bureau has leased with the privilege of renewal for 20 years. This building will house a chemical laboratory, a parasite-rearing laboratory, a laboratory for the study of bacterial, fungus, virus, and other diseases of the pink bollworm, and an insect physiology laboratory. A separate building houses the toxicology laboratory where intensive studies are being made of conventional and systemic insecticides against the pink bollworm. A half-acre cage, completely screened on the top and sides, is also being built. Heavy concentrations of insects on growing cotton can be maintained in this cage throughout most of the year. A greenhouse in which cotton may be grown the year round is planned for early construction. Plans are being made to house in a separate building at the laboratory site five bioclimatic cabinets for pink bollworm and Mexican fruitfly research. A sub-laboratory is being established at Lubbock, Tex.

Most pink bollworm research activities were conducted in the Lower Rio Grande Valley and in the Coastal Bend area of Texas in cooperation with the Texas Agricultural Experiment Station, the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the National Cotton Council of America. The latter agency, through the Oscar Johnston Cotton Foundation, appropriated the sum of $50,000 to be used in support of this research.

Pink bollworm causes heavy commercial damage to cotton in southern Texas

The heavy carryover of pink bollworms from the 1951 crop resulted in the heaviest infestation on record in northern Mexico and southern Texas in the 1952 crop. Surveys made immediately after the 1952 crop was harvested indicated that the average reduction in yield due to the pink bollworm in 38 counties in southern Texas was 12 percent. The damage ranged from extremely light in some of the northern counties to as high as 26 percent in Cameron, the southernmost county in Texas. More than 90 percent of the crop was destroyed in some of the heavily infested fields. The estimated crop loss from the pink bollworm in southern Texas, including reduction in yield, damaged to fiber and seed, and cost of insecticides for control was $31 million. This was the first year that serious commercial damage by this insect has occurred over a considerable area in the United States.

Inspections disclose many newly infested areas

All cotton-growing counties of any consequence in Texas are now infested with the pink bollworm. The infestation is especially serious in 45 counties. Inspections for pink bollworm in the 1952 cotton crop resulted in the finding of infestation in 41 heretofore uninfested counties in Texas, 37 of which were east of the former regulated area and 4 in the extreme northwestern part of the State. New infestations were also found in a parish in northwestern Louisiana, in six counties in Oklahoma, and one in southern Arizona. In newly infested areas of east Texas, Louisana, and Arizona, intensive field inspections were made in an effort to locate all infested fields which might serve to carry over the infestation into the 1953 crop. With such fields as focal points, farmers were urged to carry out recommended cleanup measures aimed at eradication.

Infestations were also found in the regulated counties in New Mexico and Oklahoma. More specimens were taken in the regulated counties of southeastern Arizona than for several years past. Only three pink bollworms were found in the regulated area of Louisiana. In border areas of Mexico, infestation was comparable to that in Texas. Infestation was slightly heavier than last year in the Laguna area, but was very light in Delicias.

Inspection of debris from the 1952 crop in the spring of 1953 showed a striking decrease in the number of living pink bollworms in the Lower Rio Grande Valley and parts of the Corpus Christi section. This was the direct result of fewer worms going into hibernation as a result of strict compliance with control practices recommended by the State and Federal control organizations.

Stalk destruction deadline met in 1952

Although dry weather in the spring of 1952 delayed planting of the cotton crop, the stalk destruction program was the most successful in many years, particularly in the Lower Rio Grande Valley. The deadline dates set by the State authorities of Texas and Louisiana were rigidly enforced. Several hundred cases were prosecuted for violations of the State law and minimum fines imposed. Only one case was flagrant. This individual was fined $1,850 and was required to spend one day in jail, in addition to incurring heavy expenses for special treatment and handling of the cotton illegally harvested.

About 250 acres were designated as a noncotton zone in Vermilion Parish, Louisiana. Reimbursement costs for compliance with the nonproduction of cotton regulations were shared equally by the State of Louisiana and the Bureau.

Cooperative pink bollworm control work in Mexico

Cooperative pink bollworm control work with Mexico continued during the year. Quarantine and cultural practices similar to those in adjacent areas in the United States were successfully carried out in the States of Tamaulipas, Nuevo Leon, and Coahuila. In this area of Mexico about 1,300,000 acres of cotton were planted, but production was reduced to 291,000 bales by drought and heavy insect damage. This area operates 129 gins, 10 oil mills, and 4 compresses.

Technical assistance in pink bollworm control and quarantine measures was given in the Laguna and Delicias areas of the State of Chihuahua, where 107 gins processed 330,000 bales of cotton.

Stalk destruction dates were the same as in adjacent areas of Texas. A generally satisfactory cleanup was obtained.

Wild cotton eradication in Florida

More then 25,000 acres in southern Florida were worked one or more times to remove colonies of wild cotton plants that are host of the pink bollworm. About 75,000 of these plants were thus destroyed. More than 3 percent of them had fruited. Matured fruits were collected and burned.

Examination of 21,740 bolls, blooms, and squares from wild cotton plants resulted in the collection of 61 pink bollworms. Infestations were found at Cape Sable and on the Main Keys between the mainland and Key West. Examination of 6,131 bolls, blooms, and squares collected from dooryard plants, which are grown as ornamentals, disclosed 610 pink bollworms. All these specimens were found on a single property in Monroe County.

Improved stalk shredders kill more pink bollworms

Studies of various types of stalk cutters have shown that the new shredder machines cut the stalks into finer pieces and that more pink bollworm larvae are killed during the cutting operation than with the conventional roller cutter. These new machines also spread the crop debris more evenly over the soil, exposing the larvae to the hot sun where many more of them are killed. They also permit better coverage in plowing.

Pink bollworm able to overwinter within present range of infestation

Hibernation cages installed in the fall of 1952 showed that pink bollworms survived the winter of 1952–53 under field conditions in southwestern Oklahoma, in northern and northwestern Texas, and in other areas of Texas where studies were made. By July 4, 1953, the total moth emergence from 80 cages containing 240 pounds of heavily infested bolls at each location was as follows: Brownsville 22, Port Lavaca 295, Waco 3,684, Greenville 1,960, Vernon 494, and Lubbock 92, all in Texas, and Chickasha, Okla., 1,051.

Ginning and oil-mill delinting destroy high percentages of pink bollworms

Preliminary small-scale experiments in northwestern Texas early in 1953 showed that high percentages of pink bollworms in seed cotton

and cottonseed are killed during the processes of ginning and oil-mill delinting of the seed. One heavily infested sample of snapped cotton containing 586 live pink bollworms to the pound of seed before ginning contained only 11 after normal ginning, 0.6 after the first cut of linters, and none after the second cut of linters. These experiments showed that ginning killed 98.1 percent, ginning plus first cut of linters 99.9 percent, and ginning plus first and second cut linters 100 percent. No live larvae were found in the lint or linters.

Cage tests determine pink bollworm emergence from gin waste

Gin waste collected from gins in several west Texas counties late in 1952 was placed in emergence cages at Lubbock. Up to July 3, 1953, pink bollworm moths had emerged from this waste as follows: 8 per 100 pounds of gin waste from Tom Green County, 3 per 100 pounds from Hockley County, and 262 per 100 pounds from Pecos County. No moths had emerged from gin waste collected in Lubbock, Gaines, Garza, and Crosby Counties.

Late-season combined pink bollworm and boll weevil treatments effective

Late or mid-season field-scale experiments in the Lower Rio Grande Valley and Coastal Bend areas of Texas showed a pronounced increase in cotton yield from pink bollworm and boll weevil control, with the greater increases from pink bollworm control. Highest gains were obtained in the Lower Rio Grande Valley, when unusually heavy infestations occurred. In three experiments boll weevil control treatments resulted in seed cotton gains over untreated checks that ranged from 37 to 471 pounds per acre, for an average gain of 251. In five experiments the gain from treatment for both insects over treatment for boll weevil alone averaged 672 pounds per acre, ranging from 349 to 1,069 pounds.

DDT applied at the rate of 4 pounds per acre every 14 days gave only slightly less pink bollworm control than 2 pounds applied at 7-day intervals. The addition of EPN to DDT increased control of the pink bollworm, gave satisfactory control of moderate boll weevil infestation, and helped suppress spider mite and aphid buildup. Even the most effective insecticide treatment did not eliminate all damage by pink bollworm. In some of the experiments there was considerable damage. Because of the extremely heavy infestation in 1952, much better control undoubtedly would have been obtained if the treatments had been started earlier.

In randomized small-plot experiments, DDT mixtures containing EPN, toxaphene, dieldrin, or endrin were effective against both the boll weevil and pink bollworm. Of the new insecticides tested CS–708 gave sufficient pink bollworm control to warrant further field trials. Metacide, endrin, and malathion did not show much evidence of control.

Light traps may assist in pink bollworm detection and control

Preliminary work with black-light and mercury-vapor lamps for attracting pink bollworm moths showed sufficient promise to justify further investigations. It was noted incidentally that the lights also attracted large numbers of such other lepidopterous insects as the bollworm, the cotton leafworm, and cutworm moths. These traps

were found to be of value in detecting pink bollworm infestations in the outlying lightly infested and in identifying noninfested areas of Texas. Pink bollworm moths were collected in traps in Fannin and Lamar Counties, which were not previously known to be infested. This work was in cooperation with the Division of Farm Electrification, Bureau of Plant Industry, Soils, and Agricultural Engineering and the Texas Agricultural Experiment Station.

Synthetic media developed for laboratory rearing of pink bollworms and boll weevils

For the first time the pink bollworm has been reared from egg to adult on a medium in which all components are known and are chemically pure. This medium is composed of dried egg albumin, dextrose, cottonseed oil, and crystalline vitamins. Physical conditions necessary for the development of the insect were also determined. The shortest period for development from egg to adult was 41 days. The average development period in the field is about 31 days.

Starting with half-grown larvae, normal adult boll weevils were also produced in a synthetic medium. Crystalline vitamins, purified dried-egg albumin, dextrose, fats, salts, and water were combined to produce a homogenous, solid, soft medium suitable for their development. Larvae were observed to feed and prepare a hollowed-out space in the medium for pupation, similar to that in a square or boll. Normal pupation and emergence occurred.

Boll Weevil Damage Relatively Light

Weather conditions during the critical fruiting period of the 1952 cotton crop were not conducive to heavy boll weevil buildup. Accordingly, the damage caused by this insect was relatively light, except in the Lower Rio Grande Valley of Texas, where severe losses occurred. Despite the relatively low damage caused by the boll weevil in comparison with previous years, experimental data at Tallulah, La., showed an average increase in yield of 18.4 percent where insecticides were used for boll weevil control. At San Benito and Brownsville, Tex., the increases in yield from a combination of boll weevil and pink bollworm control averaged 97.3 and 288 percent, respectively; while at Florence, S. C., the average increase from cotton-insect control where the boll weevil was the principal pest was 30 percent.

Stalk Destruction Important in Boll Weevil Control

Just how essential cotton-stalk destruction is in boll weevil control was amply demonstrated in the Lower Rio Grande Valley of Texas during 1952. For several years practically all cotton stalks in that area had been destroyed by August 31, the deadline imposed by the pink bollworm quarantine regulations. During the years when this stalk destruction was accomplished by the deadline date, the boll weevil problem was minimized during the following year and comparatively light damage resulted. In the fall of 1951, however, owing to unfavorable weather conditions, the deadline date for stalk destruction was extended and a thorough job of destroying the stalks was never accomplished. As a result, many boll weevils survived the

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winter and the damage caused by this insect in 1952 was extremely heavy.

Spray Combinations Effective Against Many Cotton Insects

Large-scale spray tests in the Lower Rio Grande Valley in 1952 indicate that spray combinations of DDT with either methyl parathion or Metacide may control the pink bollworm, boll weevil, cotton aphid, bollworm, cotton leafworm, and spider mites. Average seed cotton yields from test fields sprayed with these combinations were almost three times the yield from untreated test areas. In one field sprayed with DDT and methyl parathion combined, a gain of 1,600 pounds of seed cotton per acre was obtained over the untreated area. All tests were in cooperation with the Texas Agricultural Experiment Station.

Spray applications were begun on April 15, when about 10 percent of the blooms were infested with the pink bollworm, and repeated about once a week until July 3. The number of applications varied from 11 in one of the fields to 3 in another, and averaged a little more than 6 per field, which was below the average for applications of other sprays on many farms where the pink bollworm was a problem in 1952. The percentage of bolls infested by the pink bollworm averaged 61.2 in the untreated areas, 15.7 in areas sprayed with the DDT-methyl parathion combination, and 14.9 in areas sprayed with DDT plus Metacide. The methyl parathion-DDT combination held the boll infestation in another test to 9 percent while that of the corresponding check area averaged 63.1 percent.

Dieldrin was added to the other materials in some of the final applications to provide better control of the heavy, late-season migration of the boll weevil. Methyl parathion in combination with DDT appeared slightly more effective against the boll weevil than the Metacide-DDT combination.

Search On for New Chemicals To Control Cotton Insects

Endrin and the diethyl analog of methoxychlor, known as Q–128, were the only new chlorinated hydrocarbon insecticides tested which showed promise for control of the boll weevil. In laboratory and field-cage tests designed to discover new chemicals that may be useful in the control of spider mites and insects attacking cotton, these compounds appeared outstandingly effective at dosages of 0.25 and 2.0 pounds per acre, respectively. This work, conducted at College Station, Tex., was in cooperation with the Texas Agricultural Experiment Station and various insecticide and chemical manufacturers.

Of the new phosphorus compounds, methyl parathion at dosages of from 0.25 to 0.5 pound per acre appeared promising. EPN and 4-methylumbelliferone 0,0-diethyl thiophosphate and their methyl analogs showed enough promise to justify further field testing. Chlorothion, a compound related to parathion, containing chlorine, also appeared promising at about 0.5 pound per acre. When nine homologous pairs of phosphorous compounds were tested against the boll weevil, the methyl homolog was in general considerably more effective than its ethyl counterpart. Several compounds have been found to have systemic activity against the boll weevil.

Insecticides Field-Evaluated Against Boll Weevil

Large-scale field experiments and small field-plot tests were conducted at Waco, San Benito, and Brownsville, Tex., Tallulah, La., Stoneville, Miss., and Florence, S. C., to evaluate several new insecticides and combinations of insecticides against the boll weevil and other cotton pests.

In the Lower Rio Grande Valley, where boll weevil damage was greatest, dieldrin gave longer residual control of the boll weevil than any of the other insecticides tested. A combination of dieldrin and DDT applied at the rate of 0.25 to 0.375 pound of dieldrin plus 1 to 1.5 pounds of DDT per acre controlled most of the major cotton insects. This combination, however, did not prevent a buildup of aphids and spider mites.

Methyl parathion appeared promising for boll weevil, cotton aphid, spider mite, and cotton leafworm control. A combination of methyl parathion and DDT at the rate of 0.15 to 0.375 pound of methyl parathion plus 0.5 to 1.5 pounds of DDT per acre was effective against all cotton pests. During heavy boll weevil migration, however, this combination was not so effective as the dieldrin-DDT combination, owing to lack of residual action of methyl parathion against the boll weevil.

Endrin applied as a spray at the rate of 0.2 to 0.5 pound per acre appeared promising against the boll weevil, bollworm, and several other cotton insects. It was not effective against the pink bollworm, aphids, or spider mites.

Isodrin at the rate of 0.2 pound per acre gave effective boll weevil control in tests conducted in South Carolina.

EPN alone gave variable results against the boll weevil, but at Brownsville, Tex., a combination of EPN and DDT at the rate of 0.5 pound of EPN to 1.5 pounds of DDT per acre appeared promising for the control of the boll weevil, bollworm, pink bollworm, spider mites, and several other cotton insects. This combination appeared weak against the cotton aphid, however.

The following insecticides applied as dusts gave satisfactory control of the boll weevil and a number of other insects: BHC containing 3 percent of gamma plus DDT 5 percent; calcium arsenate applied alternately with BHC containing 3 percent of gamma plus DDT 5 percent; lime-free calcium arsenate containing 1 percent of parathion; aldrin 1.5 to 2.5 percent plus DDT 5 percent; dieldrin 1.5 to 2.5 percent plus DDT 5 percent; and toxaphene 20 percent. Forty percent of sulfur was added to the organic mixtures to suppress spider mite buildup.

Four sprays made from emulsion concentrates gave satisfactory control of the boll weevil and several other cotton insects. These, in per-acre dosages, were: 2 pounds of technical toxaphene plus 1 pound of DDT; BHC at 0.3 pound of the gamma isomer plus 0.5 pound of DDT; 0.25 pound of aldrin plus 0.5 pound of DDT; and 0.15 pound of dieldrin plus 0.5 pound of DDT.

Satisfactory Bollworm Control Obtained With Several Sprays

Endrin was the only new insecticide tested that showed promise in controlling bollworms. It was ineffective in some tests as a dust. When applied in a spray at the rate of 0.2 to 0.25 pound per acre,

satisfactory control was obtained over rather wide areas. This material will be used in large-scale experiments against bollworms in 1953.

DDT applied in a dust or spray at the rate of 0.75 to 1.5 pounds per acre gave satisfactory bollworm control. Toxaphene dust applied at the rate of 2 to 3 pounds of the active ingredient per acre gave satisfactory control in most cases. When used in a spray, however, it was necessary to add from 0.5 to 1 pound of DDT per acre for satisfactory results.

Extra Spray Required To Control Migrating Cotton Fleahoppers

Infestations of the cotton fleahopper were generally higher in Texas and Oklahoma during 1952 than in the two preceding years. This was disclosed by cotton-insect surveys, during which more than 10,000 fields in Texas and 1,300 in Oklahoma were inspected for fleahoppers. These pests emerged largely from horsemint and croton during April and May, and moved into cotton in injurious numbers after early season treatments had been applied. In many areas this necessitated an additional application of insecticide specifically for the cotton fleahopper. One application of toxaphene at 0.75 pound per acre during June gave good fleahopper control in most fields.

Good initial kill of the cotton fleahopper was obtained in large-scale experiments with the following materials and per-acre dosages: Toxaphene 0.75 pound; dieldrin 0.1 pound; aldrin 0.125 pound; heptachlor 0.125 pound; endrin 0.1 pound; isodrin 0.1 pound; BHC at 0.15 pound of the gamma isomer plus DDT 0.25 pound; EPN 0.125 pound; and Metacide 0.16 pound. Results observed 6, 10, and 13 days after treatment indicate that the best residual control was obtained with toxaphene, dieldrin, and endrin. BHC plus DDT gave fair residual control. Residual control from the other materials was poor. Such carryover action is quite important in areas where the cotton fleahopper may require attention in mid-season. At that time one light application of an insecticide that will control the insect is preferable in order that the beneficial insect population may be disturbed as little as possible.

Insect Problems in Irrigated Cotton Areas

Many new cotton insect problems have developed during recent years in irrigated areas of the Southwest. Several kinds of stink bugs, stainers, and other native plant bugs that ordinarily feed on weeds and cultivated plants have become serious pests of cotton. Among these are the Say stink bug, the conchuela, the brown stink bug, lygus bugs, the cotton fleahopper, and the Arizona cotton stainer. Recent investigations have shown that the shedding of many squares and bolls and the poor quality of irrigated cotton, formerly attributed to physiological conditions of the soil and plant, are caused by these insects.

Early spring surveys for plant bugs were made in Arizona in cooperation with the Arizona Agricultural Experiment Station on both wild and cultivated host plants. These showed that plant bugs, especially lygus bugs, were much more abundant than in the preceding year. This was especially true in the Salt River Valley. Both lygus and stink bugs invaded the irrigated cotton fields in rather large num-

bers in many areas early in the season, but were brought under control with insecticides. Mid-season and late-season infestations were very low, with the exception of localized areas, one of which was in the Safford Valley. Stink bugs were found in many fields when the cotton was still in the seedling stage. Fortunately they soon moved on, causing little or no damage.

DDT continued to be effective against lygus bugs. A mixture containing 5 percent of DDT plus sufficient BHC to give 2 percent of gamma proved very effective against both lygus and stink bugs. Toxaphene was also effective against lygus but inferior to the DDT-BHC mixture against stink bugs. Experiments showed that dieldrin applied at the rate of 0.25 pound per acre was effective against lygus. For stink bugs the amount had to be increased to 0.5 pound.

Sprays Give Good Initial and Residual Control of Thrips on Cotton

Thrips control experiments were conducted near Waco, Tex., both small plots and large fields being utilized. The predominant species of thrips was *Frankliniella exigua* Hd., with *F. fusca* (Hd.) present in smaller numbers. Good control of thrips was obtained with the following spray treatments and per acre dosages: dieldrin 0.1 pound; toxaphene 0.75 pound; aldrin 0.125 pound; heptachlor 0.125 pound; and EPN 0.25 pound. Satisfactory initial control with poor residual action was obtained with 0.15 pound of the gamma isomer of BHC plus 0.25 pound DDT; 0.15 pound of the gamma isomer of BHC; EPN 0.125 pound; endrin 0.1 pound; and isodrin 0.15 pound.

Unusually Heavy Spider Mite Infestations in Cotton

Spider mite infestations were unusually heavy in most cotton growing areas in 1952, necessitating the widespread use of control measures. In experiments conducted at Stoneville, Miss., and Waco, Tex., Systox at 0.25 pound per acre gave excellent initial control and was residually effective up to 15 days following treatment. Either EPN or methyl parathion at 0.25 pound per acre gave good control, but neither was as residually effective as Systox. Parathion and Metacide each gave good initial kills but reinfestations occurred in 4 to 7 days. Aramite at 0.3 to 0.5 pound per acre gave fair to good control after about 4 days, but in about 2 weeks the population increased rapidly. Malathion at 0.34 pound; R–242 at 0.5 to 1 pound; and *p*-chlorophenly *p*-chlorobenzene sulfonate at 1.5 to 2 pounds per acre each gave fair to good control.

FOREST INSECTS

Ponderosa Pine Susceptibility to Beetle Attack Depicted by Foliage Color

Foliage color has proved one of the important tree characteristics in classifying ponderosa pine according to its susceptibility to western pine beetle attack. A technique which involves black and white photographic enlargements into which color is worked by hand processing has been devised for properly depicting risk classes in color.

Available Soil Moisture Closely Associated With Bark Beetle Attack

Continuous studies have been under way for more than 10 years in northern California to determine the relation of climate to damage by bark beetles. An analysis of records obtained indicates that available soil moisture is the dominant climatic factor associated with bark beetle injury. During the 10-year period 88 percent of the annual loss was correlated with temperature, precipitation, and the resulting soil moisture during the growing season.

New Epidemic of Engelmann Spruce Beetle in Northern Rockies

An epidemic outbreak of the Engelmann spruce beetle occurred early in the summer of 1952 in spruce forests throughout northern Idaho and northwestern Montana. This outbreak probably developed in tremendous numbers of spruce uprooted by hurricanelike winds in November 1949. The Colorado outbreak of this beetle, which developed in windthrown timber following a blowdown in 1939 and eventually destroyed 4 billion feet of valuable timber, subsided in 1952 following an extensive program of chemical control plus the destruction of large numbers of the beetle by abnormally low winter temperatures and by woodpeckers.

Simplified Engelmann Spruce Beetle Spray Fulfills Expectations

Previous reports have called attention to the effectiveness of ethylene dibromide emulsions in controlling the Engelmann spruce beetle. Inasmuch as this formula utilizes water rather than oil, its development was considered to represent a progressive step in the search for more economical methods of control. The new emulsion formulation was tested in the field in 1952, being used in two control projects in Colorado, in cooperation with the Forest Service. Approximately 40,000 gallons of this emulsifiable concentrate containing 3 pounds of ethylene dibromide per gallon was prepared at Denver, Colo., for use in these tests. The emulsion fulfilled all expectations, not only as an effective bark beetle insecticide but also as a relatively pleasant and safe formulation for control personnel to apply. Tests were initiated on the usefulness of glycidyl phenyl ether and epichlorohydrin in preventing corrosion of tin plate containers by the formulation, which is packed in gallon cans for field use.

Trap Trees May Be Useful in Engelmann Spruce Beetle Control

Studies begun in Colorado in 1951 were continued in cooperation with the Forest Service to determine the possibility of obtaining control of the Engelmann spruce beetle by the systematic felling of trees and their subsequent removal from the stand after beetle attack and prior to beetle emergence.

Several thousand trees were felled and left in the woods until the end of the 1952 beetle flight season, at which time they were examined for evidence of attack. Despite a light infestation of spruce beetles in 1952, it was found that even where practically all felled trees were infested, only 2 percent of the standing green trees were infested. These results, while not demonstrating the value of this

method of control, do suggest the possibility of preventing epidemics by capturing and destroying a major part of the beetles present in light infestations.

Two Nematodes Found Parasitizing Engelmann Spruce Beetle

Recent studies of the effect of biological control factors on Engelmann spruce beetle infestations in Colorado show that two species of nematodes, *Aphelenchulus reversus* and *Parasitylenchus* (new species), parasitized approximately 20 percent of the beetles in 1952. Laboratory studies showed that egg production by infested female bark beetles was reduced as much as 90 percent. These limited studies indicate that these nematodes may be of real importance in limiting bark beetle populations.

Pacific Northwest Has Its Worst Epidemic of Douglas-Fir Beetle

What has been characterized as the worst epidemic of the Douglas-fir beetle ever recorded in the Pacific Coast States occurred in 1951. The epidemic originated in the hundreds of thousands of Douglas-fir that were blown down in the Pacific Northwest during severe windstorms in 1949 and 1950. In 1951 more than a billion board-feet of valuable timber was beetle killed. During the winter of 1951–52 a second windstorm occurred, adding still further to the huge volume of beetle-breeding material in the region. Indications are that the epidemic will continue for several years.

To determine the feasibility of aerial mapping and counting of trees killed by this beetle, Bureau personnel cooperated during 1953 with a timber company, the Oregon State Board of Forestry, and the United States Forest Service in an aerial survey. The results showed that, following a short period of training, qualified men could accurately map and make direct counts of beetle-killed trees over large areas from the air. To apply this technique it was necessary that the observation plane have good forward and lateral visibility and a slow-cruising speed of 60 to 70 miles per hour. Topographic maps or small-scale aerial photographs of at least 1-inch-per-mile scale are required for the area to be flown. The height of flight should be kept to a minimum of about 800 feet above the treetops. A ground check of each observer's work must be made to establish an air-ground correction factor for the counts of beetle-killed trees.

Bark Beetle Ground-Survey Methods Improved

Ground crews surveying Black Hills beetle infestations in the central Rocky Mountains have found no significant difference in effectiveness of the survey when stands are cruised in strips ½ or 1 chain wide or when lines of plots of 0.1, 0.2, or 0.25 acre are tallied. The ½-chain strip and the 0.1-acre plot can be surveyed faster than any of the others, provided the same length of line is used. In a direct comparison of the ½-chain strip and the 0.1-acre methods, it was found that the former is faster, although not significantly so. Since it is easier to train personnel to do the strip rather than the plot survey, the former method will be used in future surveys.

Same Recommendations Continue for Black Turpentine Beetle Control

Best results in preventing attack by the black turpentine beetle in Mississippi were still obtained with a 10-percent dust and sufficient BHC to give 0.25- and 0.50-percent concentrations of the gamma isomer in oil. If either of these materials is applied to stumps immediately after trees are cut, breeding by this beetle is prevented. The stump loses its attractiveness before the insecticide loses its power to kill attacking beetles.

Residual Sprays Toxic to Western Pine Beetle

Residual sprays of DDT, BHC, and lindane on the bark of pines are toxic to western pine beetles after 60 seconds of contact, according to observations in southern California. Residues are even more toxic to the California five-spined engraver beetle. These sprays are being considered from the standpoint of effectiveness and cost of application as a substitute for the fell-peel-burn and penetrating-oil-spray control methods now in use.

Artificial Virus Infection Highly Lethal to European Pine Sawfly

A 1952 infestation of the European pine sawfly on red pine in New Jersey was artificially controlled with virus particles by airplane spraying. This work was done in cooperation with the New Jersey Department of Agriculture and the Canada Department of Agriculture. The virus in a water suspension was applied at the rate of about 2 gallons per acre, each gallon containing about 2.5 billion virus particles. Excellent control of the sawfly was obtained. A water suspension of this material was also applied as a fine mist to infested red pines on Henderson State Forest, Illinois, in cooperation with the State Division of Forestry, the State Entomologist of Illinois, and the Natural History Survey of Illinois. Results there were also highly satisfactory.

Tent Caterpillars Absolved in Wild Black Cherry Destruction

The widespread dying of wild black cherry trees in New England cannot be attributed to the eastern tent caterpillar, although these trees have long been known to be a favored host of this insect. Nor can it be attributed to any other insect species. This was disclosed as the result of a recently concluded 10-year study in cooperation with Harvard University Forest to determine whether the heavy losses of young trees of this species in New England were caused by tent caterpillar feeding.

Treated Wood Still Termiteproof After Twenty Years

Sections of trees treated by steeping in various chemicals for termite protection were placed in contact with the ground at Asheville, N. C., Santee, S. C., and Saucier, Miss., in 1933. It was found that 75 to 80 percent of those that had absorbed mercuric chloride or sodium arsenite at the rate of 1½ pounds per cubic foot were still serviceable.

About 50 percent of those treated with either 1½ pounds of copper sulfate, 1¾ pounds of zinc chloride, or ½ pound of sodium arsenite per cubic foot were still serviceable. Treatments applied in the spring of the year were much more effective than those applied in late summer or early fall.

Soil Poisons Developed for Termite Protection

DDT and BHC are being studied with a view to preparing formulations of each that will provide protection from termites for 10 years or longer when used as a soil poison. In Mississippi, 8 percent of DDT in fuel oil continues to give effective protection 8 years after its application; also sufficient BHC to give 0.8 percent of the gamma isomer in kerosene has given complete protection for 6 years. Tests with chlodane, dieldrin, and aldrin show that these materials are also effective as soil poisons for termite control.

Termite Treatment Developed for Wallboard and Insuation Panels

Samples of wallboard and insulation panels made of wood pulp or agricultural waste, treated with 10-percent sodium arsenite and 2-percent copper naphthenate, were only lightly attacked by termites and decay organisms after 4 years of direct contact with the soil. Untreated samples were very susceptible to termite injury, and were heavily damaged in 1 year.

Spray Reduces Feeding of Dutch Elm Disease Vector

A 9-percent methoxychlor residual spray, applied with a mist blower, may be fully as effective in preventing feeding by the smaller European elm bark beetle—one of the carriers of the Dutch elm disease fungus—as a 12-percent DDT emulsion residual spray. This was shown by spray tests performed in the District of Columbia, in cooperation with National Capital Parks, United States Department of the Interior. There was nearly 100-percent reduction in feeding for 100 days after either type of spray was applied, and about 70-percent reduction for 150 days.

Several of the newer insecticides were tested in separate small-scale tests at Columbus, Ohio, for residual control of the smaller European elm bark beetle. For 68 to 75 days after spraying, formulations of methoxychlor, dieldrin, TDE, and DDT were almost completely effective in preventing feeding.

Special Device Converts Helicopter to an Airborne Mist Blower

What is in effect an airborne mist blower has been developed for control of the smaller European elm bark beetle. This consists of a new type of spraying device attached to a helicopter. In tests at Medfield and Norwood, Mass., in cooperation with an airline, the Massachusetts Department of Conservation, and the Connecticut Agricultural Experiment Station, it was found that as good results could be obtained with this device as with hydraulic sprayers. Helicopter sprayers provide heavier deposits in the tops of trees than do hy-

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draulic sprayers; furthermore, the spray run-off is eliminated. On the other hand, there is less deposit on the lower parts of the crowns of trees when treated by helicopter.

Highly Atomized Aerial Spray Gives Most Uniform Distribution

Further efforts were made to determine the degree of atomization most effective in airplane spraying of insect-infested forests. Sprays of three degrees of fineness were tested—80, 150, and 300 microns mass median diameter. The finest spray provided the most uniform distribution across the swath and the least overdosing at points of maximum deposit in the swath. The percentage of spray reaching the ground was approximately the same for all three degrees of atomization.

Dyed Cards Used to Check Sufficiency of Aerial Spray Deposits

Special paper cards coated with a dry oil-soluble dye are useful in intercepting falling spray and detecting unsprayed areas in aerial spraying operations. It is essential that unsprayed areas as well as those receiving inadequate coverage be detected in airplane spraying operations against such forest insects as the spruce budworm. Re-runs by the spray planes are then made over such areas to assure their coverage. When a drop of spray falls on the dyed card it makes a distinct circular mark on the card surface. The size of the drop and the amount of spray it contains can then be estimated with satisfactory accuracy by comparison with other cards previously treated with drops of known sizes and known quantities of spray. Under actual field conditions these cards have been read at the rate of 300 per man-hour. These experiments were performed in cooperation with the Division of Forest Biology, Canada Department of Agriculture.

Benefits of Airplane Spraying for Spruce Budworm Control Persist

Surveys of the presence of the spruce budworm were made during 1952 in several forest areas in Oregon and Washington that were sprayed in 1949 and 1950 by airplanes for spruce budworm control. With the exception of small areas where spraying was done too late to be fully effective, it was found that control remained generally effective with no serious reinfestation.

INSECTS AFFECTING MAN

Mosquitoes Tested for Insecticide Resistance

Outstanding results were obtained with EPN emulsions or wettable powder sprays when applied with airplanes or ground equipment in field studies during the summer of 1952 to determine the value of phosphate insecticides for the control of insecticide-resistant mosquitoes. These investigations, in cooperation with the California Department of Health, were part of the continued study at the Corvallis, Oreg., laboratory to determine the degree of resistance that mosquitoes have developed to DDT and other new insecticides. These studies were prompted by the fact that control of *Culex tarsalis*, *Aedes nigro-*

maculatus, and *A. dorsalis* mosquitoes in irrigated regions of the Central Valley in California is becoming increasingly difficult.

Tests with EPN showed that rates of application as low as 0.035 pound of the insecticide per acre completely controlled the mosquito larvae. In large-scale control operations a dosage of 0.075 pound per acre gave excellent results. EPN is regarded as one of the more hazardous insecticides. However, the rates required for mosquito larva control are only about one-fourth to one-third the rates of DDT and toxaphene. Operators applying EPN in the cooperative work in California experienced no toxic reactions to this insecticide. It is believed that careful handling of the insecticide by experienced mosquito control workers will permit its safe use. The material has not yet been recommended for such use.

Malathion and tetrapropyl dithiopyrophosphate, two other phosphate insecticides that are much less hazardous to man and animals, gave good control of mosquito larvae at dosage rates of 0.4 to 0.5 pound per acre.

Heptachlor gave excellent control of larvae and adults of *Aedes* mosquitoes in Oregon. The dosage rates required ranged from 0.1 to 0.15 pound per acre. Chlordane proved somewhat less effective than heptachlor.

Successive generations of colonies of *Culex quinquefasciatus* mosquitoes have been exposed to EPN and DDT in the larval stage in an effort to determine the capacity of this species to develop resistance to these two insecticides. The rapidity and degree to which mosquitoes develop resistance to insecticides are criteria that must now be considered in determining the value of new insecticides for mosquito control. There have been no conclusive results from these studies to date.

There has been a need for economical and practical mosquito-control methods in small communities not having funds or technical leadership for consistent control programs. As a demonstration of control work possible in such a community, a residual DDT spray was applied to a village in eastern Oregon. Two applications of spray to the entire community during the mosquito season provided good protection to the inhabitants. Residual spraying without larviciding may also retard the development of resistant mosquitoes.

Insecticides Highly Effective in Destroying Imported Fire Ant Colonies

Investigations at Mobile, Ala., to develop more satisfactory methods for controlling the imported fire ant showed that for individual mound treatment, a concentration of 0.25 percent of chlordane, dieldrin, aldrin, or heptachlor may be used with equal effectiveness in controlling this destructive, introduced pest now widespread in the Southern States. The research was done in cooperation with several State agencies in Alabama. Water emulsions or suspensions containing the 0.25-percent concentration should be applied at the rate of about 3 gallons per mound. Two insecticides, EPN and parathion, at concentrations as low as 0.03 percent, were also highly effective. These materials are also highly toxic to man and animals. It is not yet certain whether they can be used without undue hazard.

When insecticides are applied uniformly to the entire surface area in the vicinity of an ant mound more lasting control is obtained. Chlordane at the rate of 2 pounds per acre will control ants for about 1 year. Dieldrin at the same rate will keep the treated area free of ants for at least 2 years.

The use of chlordane in combination with fertilizer, applied at the rate of 1 pound per acre, protected germinating seed corn from attack by the ants.

Heptachlor Effective Against Sand Flies in Florida

Studies on sand flies in Florida showed 74 percent reduction of larvae after 2 weeks and 88 percent reduction after 14 weeks when a large area was treated with heptachlor at 2 pounds per acre in an oil solution. In a smaller test, 1 pound of heptachlor in 10 pounds of granulated bentonite per acre showed 81 percent control after 22 weeks. At twice this dosage 93 to 100 percent control was achieved through 22 weeks. This work was supported in part by military funds and in part by the Florida State Board of Health and several mosquito control districts in Florida.

Insecticides Tested Against Salt-Marsh Mosquitoes

In extensive tests in Florida the most effective insecticides for use in mist sprayers and fog machines against adult salt-marsh mosquitoes were gamma BHC, heptachlor, DDT, dieldrin, and chlordane. There was little consistent difference between two commercial fog machines, a Japanese Kyoritu fog machine and a mist sprayer developed by Bureau personnel. This work was supported by funds made available to the Bureau from the Department of Defense.

Orlando Facilities Expanded

Six buildings at Orlando, Fla., were acquired under permit from the Department of Defense for the use of the Division of Insects Affecting Man and Animals. This move, from other quarters at Orlando, permits the use of more land and building space and furnishes better facilities away from residential areas. Future costs to the Bureau will be for building maintenance only.

INSECTS AFFECTING LIVESTOCK

Various Insecticides Tested Against Livestock Pests

A technique has been developed by which various insecticides and repellents can be tested in a preliminary way for horn fly or stable fly control on cattle by treating an area about 6 inches square on the animal. In this way as many as 12 or more formulations can be tested on a single individual. This technique reduces cost of maintaining and handling animals and permits tests with small quantities of chemical. Several experimental pyrethrum synergists have been shown by these tests as worthy of further trials.

CS–708, one of the new insecticides, was found to be as effective as methoxychlor in controlling the horn fly on dairy cattle.

Methoxychlor used as a spray at a concentration of 2 percent proved effective for the control of sticktight fleas in two heavily infested poultry houses.

Various tick insecticide formulations that might be used effectively and safely in dipping vats were field tested at the Kerrville, Tex., laboratory. Improved commercial toxaphene emulsions have been studied as a dip. Analyses of hair samples from cattle periodically dipped in the vat show that there is a gradual increase in the rate of toxaphene deposited on the animals. The general appearance and resuspension properties of the emulsion are good. Dip formulations of this type may prove safe for use in vats provided its use is limited to one season of about 6 months duration. Observations of wettable-powder dip containing sufficient BHC to give 0.025 percent of the gamma isomer plus 0.5 percent of DDT have continued for a year. Although there was a gradual decline in the concentration of the insecticide, the preparation provided satisfactory control of ticks, horn flies, and goat lice during this period. The insecticide went back into suspension fairly well when the dip was agitated. A commercial toxaphene wettable power dip has also been under observation for several months. The dip apparently gives satisfactory performance, although the insecticide is difficult to resuspend after it settles in the vat.

Injections of Insecticides Into Animals To Control Insect Pests

A promising lead in research efforts to control bloodsucking insects of cattle was attained this year. Lindane was injected into cattle at a rate of 50 mg. per kilogram of body weight. Mosquitoes, deer flies, and horn flies taking blood from injected animals were killed, although the results were not 100 percent perfect. In two animals 60 to 70 percent of the mosquitoes feeding were killed over an 18- and 21-day period.

Investigations in cooperation with the Bureau of Animal Industry have demonstrated that subcutaneous injections of aldrin and lindane in cattle at the rate of 50 mg. per kg. of body weight and dieldrin at the rate of 25 mg. per kg. killed most of the cattle grubs in the backs of cattle. A few larvae matured but failed to produce flies.

Further tests with systemics, conducted in cooperation with the Bureau of Animal Industry, demonstrated that dieldrin, aldrin, and lindane in peanut oil administered subcutaneously to cattle at dosages of 25 to 50 mg. per kg. of body weight protected cattle from screw-worm attack for 2 to 4 weeks. Even after the treatments lost their effectiveness against the larvae, flies failed to emerge from pupae developing from matured larvae for an additional period of about 2 weeks. Before these materials were administered to cattle, preliminary tests were made on guinea pigs. Further research will be required to determine if systemics are practical as a means of protecting animals from screw-worm attack.

It should be emphasized that these chemicals are not recommended for use in these ways. The results obtained are important because this is the first demonstration that injections of chemicals will kill cattle grubs. Much research needs to be done to find safer and more effective compounds.

Screw-Worm Sterilization Studies Continued

A field test has been conducted to determine whether the release of sterilized male screw-worm flies on an island at a rate of about 10 times the natural population would reduce fertile egg production. The test was conducted during the winter of 1952–53 on Sanibel Island and adjoining Captiva Island, 2 to 3 miles off the coast of Fort Myers, Fla., where a natural screw-worm population was present. Sterile males were released at a rate of 100 per square mile per week for a period of about 17 weeks. During the first month of releases about 80 percent of the egg masses deposited by wild flies on wounded goats were sterile. Subsequently only a few viable egg masses were collected and these probably came from flies migrating to the island. If the island had been completely isolated from any other fly source, elimination of the fly would probably have been accomplished.

On Captiva Island where a higher natural population existed, only about 35 percent of the wild females deposited infertile eggs. Available information indicates that the natural population on this island was much higher per unit area than the Statewide average in Florida.

TOXICOLOGY OF INSECTICIDES

Methoxychlor-Sprayed Hay Safely Fed to Dairy Cows

It is highly unlikely that methoxychlor would be excreted in the milk of cows fed forage sprayed with recommended amounts of methoxychlor. Studies on the toxicology of some of the new insecticides when ingested by dairy cattle were made at Beltsville, Md., in cooperation with the Bureau of Dairy Industry. In one series of experiments alfalfa hay containing methoxychlor residues ranging from 16 to 109 p. p. m. was fed to dairy cows for periods of 40 to 80 days. Samples of milk from the cows were analyzed at 10-day intervals. No methoxychlor could be detected in the milk. The amount of methoxychlor present in those experiments equals the maximum likely to be encountered on forage treated for insect control. When methoxychlor dissolved at a concentration of 10 percent in soybean oil was fed at rates of from 1 to 15 grams of methoxychlor daily, no methoxychlor was detectable in the milk at dosages as high as 6 grams. When dosages of 8 to 15 grams daily were fed, methoxychlor found in the 4-percent fat-corrected milk ranged from 0.18 to 1.18 p. p. m. Approximately 100 times as much methoxychlor as DDT must be administered orally for this insecticide to be detectable in the milk of dairy cows.

Similar dairy-cattle-feeding studies were undertaken with aldrin, dieldrin, and heptachlor. Increased organic chlorine content of the milk of the cows on the higher levels of aldrin intake indicated the presence of this insecticide in the milk. The cow receiving a high intake of 1 gram per day died. High organic chlorine content of the fatty tissues of this animal indicated the storage of appreciable quantities of this material in the animal's body. The experiments with dieldrin and heptachlor are still in progress. Results to date indicate that a low intake of dieldrin will cause excretion of this material in the milk. Heptachlor is apparently metabolized into an epoxide compound and excreted in the milk.

A study of the effect of lindane on the flavor of milk was made. It was definitely established that an abnormal flavor exists in milk when lindane is fed at high levels of intake. However, it seems highly improbable that the feeding of forage sprayed with recommended amounts of lindane would cause excretion of enough lindane in the milk to produce objectionable off-flavors.

Toxicological Effects of Insecticides on Livestock Investigated

Investigations of the toxicological effects on livestock of a number of the newer insecticides when applied externally to the animals or ingested in the feed were made at Kerrville, Tex., in cooperation with the Bureau of Animal Industry.

When toxaphene was fed at a dosage of 100 p. p. m., storage of the insecticide in the fat of sheep reached a level of 22 p. p. m. in 28 days. There was no significant increase in toxaphene deposit during the remainder of the 112 days' feeding period. When feeding of the insecticide was stopped, the residue dropped about one-half in 4 weeks and was eliminated in 8 weeks. The same dosage fed to calves caused 33 p. p. m. storage in the fat at the end of 56 days' feeding. The storage level did not increase above the limit of experimental error during the remainder of the 112-day feeding period. After the feeding of the insecticide was discontinued the residue decreased to about one-third in 4 weeks and was practically eliminated in 8 weeks.

BHC fed to sheep at a dosage of 100 p. p. m. resulted in the storage of the insecticide in the fat to the extent of 120 p. p. m. after 56 days' feeding. There was no significant increase during the remainder of the 112-day feeding period. When the sheep went on an insecticide-free diet, the residue decreased to 32 p. p. m. in 8 weeks and was practically eliminated in 16 weeks.

When aldrin was fed at a dosage of 25 p. p. m. to calves and sheep there was a continuous increase in the insecticide stored in the fat to the end of the 56-day feeding period. The maximum storage was 78 p. p. m. for both sheep and calves. When feeding of the insecticide was discontinued there was a gradual decrease in the residue in the calves to 8 p. p. m. in 32 weeks. Since this appeared to be an excessive aldrin content after such a long period, the sheep in this group were slaughtered 4 weeks later in order to get larger and better fat samples for analysis. Analyses of these latter samples confirmed the previous results.

Although dieldrin was fed at only one dosage, 25 p. p. m. in the diet, the amount of storage in the fat of both sheep and calves was practically the same as was obtained from feeding this same dosage of aldrin.

No detectable methoxychlor residue was present in the fat of sheep or calves after feeding 10 p. p. m. of the insecticide in the diet for 28 days. Similar results were obtained with toxaphene.

Ten p. p. m. of DDT in the diet of sheep and calves for 28 days caused DDT storage in the fat amounting to 3.1 and 6.8 p. p. m., respectively.

When chlordane was fed at a dosage of 25 p. p. m. in the diet for 56 days, storage of the insecticide in the fat reached a maximum of 18.5 p. p. m. for the calves and 12.5 p. p. m. for the sheep. The residue

was eliminated by the sheep 4 weeks after the feeding of the insecticide stopped. On regular diet, residue in the calves decreased to 5 p. p. m. in 8 weeks and was completely eliminated in 20 weeks.

These results show that the sequence of these insecticides ranging from those causing the lowest residues to those resulting in the highest residues is methoxychlor < toxaphene < DDT < chlordane < dieldrin, aldrin, and BHC.

A further study was made at Kerrville in cooperation with an insecticide manufacturer on the excretion of CS–708 in milk following spraying of dairy cows. Sprays containing 0.5 percent of this material were applied to two cows at two-week intervals. The amount of insecticide detected in the milk reached a maximum one or two days following spraying. The largest amount found was 1.36 p. p. m. After two weeks that amount dropped to about 0.3 to 0.7 p. p. m., and three weeks after spraying was down to 0.24 p. p. m.

Investigations were continued to determine the extent of storage of insecticide residues in the fat of animals and the extent of secretion of such residues when the insecticides are applied to animals. In cooperation with an industrial company, a special toxaphene emulsion concentrate being developed for use as a dip and spray was applied to cattle as a 0.5-percent spray at two-week intervals for 12 treatments. Biopsy samples were taken at intervals during the experiment. Chemical analyses of the samples showed that there was no significant storage of toxaphene in the fat during the first 2 or 3 treatments. After 11 or 12 treatments the storage averaged about 11 p. p. m., based on organic chloride determination. The toxaphene largely disappeared from the fat six weeks after treatments were discontinued. These results largely confirm previous investigations with similar toxaphene formulations.

Geese Most Susceptible to Aldrin and Toxaphene

Toxicity tests were run on geese to determine their resistance to the insecticides used in cotton fields. Use of geese to destroy weeds in such fields is quite widely practiced in some areas. It has been suspected that such geese may at times be poisoned by the dusts and sprays used. Tests showed that oral administration of 10 mg. per kilogram of body weight of aldrin and toxaphene will kill geese. DDT and BHC caused no toxic reactions when administered as single doses of 4,400 and 2,000 mg. per kilogram, respectively. Although experiments could not be designed to simulate exposures that occur in cotton fields, the information obtained showed that among the cotton insecticides tested, aldrin and toxaphene are more likely to cause poisoning of geese than DDT or BHC.

CS–708 Studied as a Dairy Barn Spray

Residue studies of CS–708 when used as a dairy spray were made in cooperation with the manufacturer. Residual spraying of dairy barns with 2.5 percent CS–708 suspension caused little or no contamination of milk from cows subsequently milked in the barns. Limitations in the accuracy of the chemical method of analysis prevented any definite conclusions as to the amount of residues, if any, which appeared in the milk.

Dieldrin-Treated Fly Strips Safe for Dairy Barn Use

Dieldrin-treated screen strips in dairy barns as a means of fly control will not cause detectable dieldrin contamination of milk of cows subsequently milked in the barns. This was learned during studies made in cooperation with the manufacturer of this product.

CHEMICAL STUDIES OF INSECTICIDES

Structural Change in Molecule Detoxifies Affinin

A number of compounds closely related to affinin, the insecticidal constituent of *Heliopsis longipes*, were synthesized to obtain information on the relationship of double bonds, geometric isomerism, and other structural details of the molecule with insecticidal activity.

The importance of geometric isomerism in the toxicity of compounds of this type was demonstrated in an experiment in which affinin, which contains at least one double bond of the *cis* configuration, was converted by exposure to ultraviolet light to "*trans*-affinin" in which all double bonds had the *trans* configuration. Although affinin is as toxic as pyrethrins to house flies, "*trans*-affinin" showed no toxicity to this insect.

Synthetic Organic Compounds Tested as Insecticides

Three hundred and thirty-eight synthetic organic compounds were prepared and submitted under code for screening tests as insecticides, synergists for allethrins and the pyrethrins, or insect repellents. These include a number of amides, esters of chloroacetic, chloropropionic, bromoacetic and ethoxybenzoic acids, and esters of phenethyl and pheylpropyl alcohols.

Sixty-two compounds that had previously been prepared and tested as insecticides and pyrethrum synergists were prepared in further amounts for testing as synergists for allethrin.

Lindane Formulations and Analysis Improved

Experiments to improve the residual properties of lindane showed that the effectiveness of deposits of this insecticide can be markedly prolonged by the addition of chlorinated terphenyls in the formulations. At the same time the appearance of residual deposits of lindane was improved by this means through the elimination of surface crystallization.

An improved method of analyzing lindane in air was developed during the year. The lindane from a known volume of air is adsorbed by drawing the air through a column af activated alumina. This means of sampling is rapid and efficient. The adsorbed lindane is then washed off the alumina with glacial acetic acid and determined colorimetrically by a method developed by Bureau chemists. This method of analysis was employed in cooperative studies on the use, for disinsectization purposes, of lindane-treated filter screens in the air-conditioning system of a Constellation airplane. It is also being followed to study the lindane-in-air concentration resulting from the use of lindane thermal generators.

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Synergists for Allethrin Evaluated

Twenty-three piperonylamides previously found to show synergism when combined with pyrethrins were evaluated in combination with allethrin. Twelve of these sprays produced house fly mortalities three or more times greater than expected on the basis of equivalents. They appear to be worthwhile allethrin synergists.

Aerosol Formulas Licensed

One hundred and forty-five aerosol formulas were submitted by industry for approval under the aerosol public service patent license. Of these, 121 were approved. The remainder were inferior to the tentative official test aerosol, or were chemically unsatisfactory. The commercially produced synthetic thiocyanate, Thanite, was permitted in household aerosols for the first time in 1952. This followed clearance on toxicological hazards by the Food and Drug Administration after entomological tests by Bureau personnel.

Parathion Purification Process Patented

A public service patent was obtained by two Bureau chemists for a process for purification of parathion.

Three Manufacturers Now Producing Bureau-Synthesized Insecticide

Allethrin, first synthesized by Bureau chemists in 1949, is now being manufactured commercially by three companies, having a total potential production capacity of 600,000 pounds per year. The United States Army has purchased large quantities of aerosols and other insecticides containing allethrin and it is also being used extensively in household aerosols.

Crops Analyzed for Insecticide Residues

Residues resulting from the experimental application to apples and peaches of dieldrin sprays for plum curculio control were determined at the Bureau's laboratory at Vincennes, Ind. Isolated plots were sprayed between April 8 and May 22, three sprays being applied to apples and five to peaches. All sprays were at the rate of 1 pound of 50-percent dieldrin per 100 gallons. Samples were collected and analyzed at intervals from the time of the final spray until harvest. No residue was detected on the peaches at harvest. Less than 0.1 p. p. m. of organic chlorine was found on the apples at that time.

Also at Vincennes an experiment was performed in which corn plants in various stages of growth were treated with DDT wettable-powder or emulsion sprays in two applications of 1.5 pounds of DDT per acre. Analyses were made of the corn kernels from these plants to determine whether any DDT might have been translocated within the plant and stored in the kernels because of their relatively high oil content. The results showed that there was no DDT either on the surface of the kernels or within them.

Residues from commercial and experimental treatments of shade-grown tobacco at Quincy, Fla., were analyzed at Vincennes. These

studies, started in 1951, were concluded this year. The analyses indicated that the tobacco, after curing and sweating, might contain from 110 to 337 p. p. m. of DDT on a dry weight basis. Residues from parathion or Metacide treatments ranged from 0.01 to 1.2 p. p. m. Organic chloride residues from TDE dust treatments ranged from 76.4 to 93.4 p. p. m. DDT residues were not appreciably affected by either barn curing or sweating. Parathion residues were reduced as much as 99 percent in both barn curing and sweating. Organic chloride residues from TDE dusts showed measurable loss in the sweating process.

A greater variety of crops was included in this year's study of residues resulting from malathion treatments of various fruits and vegetables. This was a continuation of the previous year's work in cooperation with the manufacturer of this insecticide. Fewer samples were analyzed this year than last. Frozen strawberries, picked 12 days after the last of two malathion dust treatments, contained 0.18 p. p. m. of malathion. Fresh, frozen, and canned peas, potatoes, fresh snap beans, and canned wax beans were free of malathion. Bartlett pears showed only 0.02 p. p. m. at harvest. Residues on alfalfa ranged from 0 to 0.5 p. p. m., but there was no correlation between the amounts applied and the residues found. Jonathan apples showed 0.1 p. p. m. at harvest. Broccoli showed a deposit of 9.2 p. p. m. immediately after dusting but had no malathion 6 days after treatment. From initial deposits of 15 to 82 p. p. m. on spinach, residues dropped to less than 1 p. p. m. 5 days after treatment.

About 2,400 samples of cherries from orchards of 27 growers in the State of Washington were analyzed at the Bureau's Yakima laboratory. This work was performed under a memorandum of understanding with the Washington Agricultural Experiment Station and the Washington Department of Agriculture. Comparisons were also made of different methods of application of insecticides for control of the cherry fruitfly. It was found that airplane applications resulted in very low deposits as compared with hand guns or air carrier type sprayers. The variation between deposits applied with the same type of equipment by different operators was enormous.

At Beltsville, Md., a study of residues of chlorinated insecticides such as DDT and TDE on tobacco was made in cooperation with several State agriculture experiment stations and tobacco companies. Analyses of untreated samples from different sources disclosed that the natural organic chlorine content of tobacco varies considerably and is sometimes quite appreciable.

Analyses were made at Beltsville of wheat and wheat products from storage bins that had been treated with DDT and of corn from a bin treated with methoxychlor. The presence of the insecticides was detected in these commodities. The amount of methoxychlor found in the shelled corn ranged from 0 to about 1 p. p. m. In the wheat, more DDT was found in samples taken near the bin wall than in the center of the bin, as was expected. The highest amount of DDT found in the wheat was about 4 p. p. m. Up to 7.5 p. p. m. was found in the bran and shorts. The highest DDT content in samples of flour made from the wheat was 0.8 p. p. m.

Samples of a great variety of crops experimentally treated with the newer insecticides were also analyzed for residues by Bureau chemists at Beltsville. These samples included wheat, barley, oats, hay, beans, peas, tomatoes, lettuce, tobacco, mushrooms, sugarcane,

potatoes, peaches, sugar beets, sorghum, cottonseed oil, soil, and calf pellets.

Corrosive Properties of Aerosol Spray Eliminated

By dissolving schradan in carbon tetrachloride and washing it with a dilute sodium carbonate solution, Bureau chemists have found that they can eliminate the corrosive properties of this insecticide on greenhouse aerosol containers. Schradan has become an important greenhouse insecticide because of its effectiveness against otherwise resistant spider mites. Its corrosiveness, however, had become a serious problem because of variation in its pilot plant production. Difficulty encountered because of the deposition of insoluble crystalline material on the walls of aerosol containers holding schradan was eliminated by placing the aerosol mixture in a large pressure tank and filtering it when transferring it to the small containers.

Three-Hour Exposure to Lindane Vapor Kills Nonresistant House Flies

House flies of a nonresistant strain were killed after 3 hours of exposure to lindane vapor regardless of the ventilation. Studies with this material were continued because of the widespread sale of lindane thermal generators. The concentration of lindane vapor in the air of rooms where these devices were in operation varied greatly because of differences in ventilation. In one set of tests a concentration of about 0.2 microgram of lindane per liter of air was found by analysis in a closed room, while the concentration was only about 0.015 microgram per liter when windows and doors were open.

Experimental Aerosol Valves Tested

New types of experimental aerosol valves designed by various manufacturers for the domestic trade were tested for leakage, particle size delivered, and delivery rate. Suggestions were made for remedying faults in the valves. The commonest cause of trouble is deterioration and failure of rubber components of the valves. The most satisfactory material for this purpose thus far tested is a synthetic rubber of about 65 durometer hardness.

New-Type Respirators Tested Against Poisonous Aerosols

A number of new respirators were tested for protection against sprays and dusts of malathion, Systox, schradan, DMC, Aramite, *p*-chlorophenyl *p*-chlorobenzenesulfonate, aldrin, and dieldrin. Special fume filters in combination with chemical cartridges are necessary to protect against sprays and dusts of malathion, Systox, and schradan. Other than malathion, Systox, and schradan, all the materials were removed by the usual paper-type filters and chemical cartridges. Several new types of respirators failed to reduce the concentration of the organic phosphorus insecticides satisfactorily because of the small surface area of their filters. Gas mask canisters commonly used in greenhouses for protection against aerosols containing organic phosphorus compounds, when tested against schradan, Systox, EPN, and malathion, reduced the vapor concentration below 1 p. p. m.

Prospective Insecticide Diluents Examined

Inert mineral materials from several sources were examined for their suitability as carriers or conditioners in the preparation of insecticide dusts and wettable powders.

A pulverized hydrous aluminum silicate from Pennsylvania that has been proposed for use as an insecticide carrier was examined and found promising.

Three new special grades of attapulgite were investigated as possible cheaper substitutes for Santocel as a conditioner for high concentration DDT wettable powders but they did not appear suitable for this purpose.

Several mineral materials from foreign countries were examined to determine their usefulness as carriers. Among these was a sample of diatomite from Guatemala examined at the request of the Foreign Agricultural Service. Results showed that it would be useful as an insecticide carrier. A clay from Honduras, and a pyrophyllite, two talcs and three clays from Paraguay—all tested at the request of the Institute of Inter-American Affairs—in general showed promise for use in insecticides. Of two samples of supposed talcs from Mexico, one was found to be true talc of standard grade but the other was a siltlike material containing little if any talc and unsuitable as an insecticide diluent.

INSECT RESISTANCE TO INSECTICIDES

Extensive Search for Insecticides Capable of Controlling Resistant House Flies

Studies are being continued in methods of controlling insecticide-resistant house flies. Hundreds of chemicals and combinations of chemicals have been studied in the laboratory and in small field tests, but none of them appears promising. Poison baits appear to offer some promise in controlling highly resistant house flies.

Insect Metabolism of DDT Apparently Not Primary Factor in Resistance

When 60 micrograms of DDT were injected into a resistant house fly, metabolism of the compound seemed to be blocked. After 48 hours most of the DDT was recovered unchanged. The presence of this quantity of DDT in the fly without causing visible signs of distress would appear to be definite proof that the ability to metabolize DDT is not the basis of resistance.

Analytical methods and techniques that have been developed for the determination of very small amounts of insecticides have proved useful in this study of penetration, distribution, metabolism, and excretion of such materials. Through the injection of measured dosages of DDT into nonresistant female house flies and subsequent analyses, it has been determined that 0.3 microgram per fly is a 50-percent lethal dosage. To a considerable degree this DDT is metabolized to DDE, a relatively innocuous compound. Some DDT is apparently metabolized to other products as yet unidentified. Some DDE and unmetabolized DDT are excreted. This work is being continued.

Further experiments showed that when DDT is injected into highly resistant flies, they metabolize it more rapidly than do susceptible flies. DDE is again the main product of metabolism, but there is also a considerable quantity of some unidentified metabolic product.

By careful dissection, the nerve ganglia of individual house flies were isolated and measured amounts of DDT applied. The ganglia of resistant flies required far more DDT to cause symptoms of poisoning and also recovered from poisoning much more rapidly than did the ganglia of susceptible individuals.

Bureau entomologists have compared the life cycles of six susceptible and two resistant strains of house flies and have found no significant difference. The percentage of resistant eggs hatched was generally lower than the percentage of eggs of susceptible strains. No difference in the iodine number of the fat from susceptible and resistant flies was found.

Attempts are being made to develop a colony of house flies resistant to allethrin. This colony is now in the eighth generation, each generation being exposed to allethrin. Some resistance is apparent but it is at a very low level.

Chlordane-Resistant Roaches Tested

In collaboration with the National Pest Control Asociation, a colony of German roaches was established in the Beltsville, Md., laboratory and tested for resistance. The ancestors of these roaches were collected at Corpus Christi, Tex., from buildings in which chlordane failed to control the pests. When compared with susceptible strains, very high resistance to chlordane and definite resistance to DDT and lindane were proved. So far as known the resistant roaches had never been previously exposed to DDT. Nevertheless they absorbed this material and metabolized it to DDE at a greater rate than the normal strain. DDE was not the only metabolic product but was the only one identified.

Physiological Data on Insects Tabulated

Tables on chemical constituents of insect blood, the chemical analysis of insect tissue, free amino acids in insect blood, and the effects of temperature on insects, were prepared by Bureau personnel for inclusion in a Handbook of Biological Data to be published by the National Research Council.

CEREAL AND FORAGE INSECTS

Grasshopper Control and Research

Upsurge in range grasshoppers predicted

Surveys throughout 26 western States in the late summer and fall of 1952 to determine the location, abundance, and species of grasshoppers indicated an increase in range grasshoppers in many areas.

The largest of the problem areas included 450,000 acres of privately owned or controlled rangeland in the Texas Panhandle, 100,000 acres in contiguous Cimarron County, Okla., 425,000 acres in northeastern New Mexico, and about 100,000 acres in southeastern Colorado.

Extensive rangeland programs completed

Unfavorable weather or other natural conditions prevented nymphs from developing normally on 250,000 acres of Texas rangeland, but the remainder of the area produced heavy populations. A total of 34,000 acres in two drought-stricken counties were sprayed cooperatively. It is expected that the untreated infested areas will require spraying in 1954 if serious damage is to be avoided.

There was no organized control work in Oklahoma, nor was the grasshopper population reduced by weather conditions. Severe drought, however, intensified the damage to the 100,000 infested acres there, indicating a more serious problem in 1954.

The carryover of grasshopper infestation into 1954 will probably include some 450,000 acres of privately owned rangeland in southeastern Colorado; 200,000 acres of public domain in southwestern Colorado; 100,000 acres of mixed ownership rangelands in north-central New Mexico; 200,000 acres of infested Federal rangeland in Idaho; 150,000 acres of National Forest rangeland in Wyoming; and approximately 225,000 acres of infested Federal rangeland in Nevada.

A highly successful cooperative rangeland grasshopper-control program was completed in New Mexico in July 1952. Aircraft sprayed 315,000 acres of heavily infested grasslands. Surveys following treatment showed the sprayed area to be free of grasshoppers. Rancher cooperators stated, "It is the best money we ever spent." Encouraged by the 1952 results, ranchers and the State of New Mexico are prepared to participate in a similar program during 1953. The work, to start after July 1, 1953, will involve control within the 425,000-acre infestation.

During the 1952 season organized control programs reduced populations in Arizona, Idaho, Montana, Nebraska, Utah, Washington, and Wyoming. In these States 323,400 acres were successfully treated with aldrin-oil spray solution applied by aircraft and ground equipment.

Grasshopper-control activities completed in the spring and early summer of 1953 included 120,000 acres in California, 34,000 in Texas, 24,000 in Utah, and 19,000 in Arizona. California and Arizona ranchers were particularly enthusiastic about the results.

Unfavorable weather reduced a rangeland infestation observed during the fall of 1952 on some 800,000 acres in western North Dakota to about 10,000 acres of spotted infestation.

Technical assistance, including surveys and demonstrations, has been given by the Bureau in crop areas involved in these programs. The cost of any extensive actual control has been borne by farmers whose lands were infested. Illustrative of results of a grower-sponsored control project is the following comment received from a director of the Kern County (California) Grasshopper Control Project: "Please allow me on behalf of the growers in the southern end of the San Joaquin Valley, Kern County, to express our sincere gratitude for the cooperation and assistance you and your staff gave us in controlling grasshoppers. * * * This project was somewhat of a departure from prior ones. We growers set out to help ourselves in order to reduce and to avoid the continuation of the usual asking of different segments of government to pay the whole bill and do the whole job. We did not succeed in this entirely, but were able to pro-

vide approximately 75 percent of the necessary funds. In this connection, we most certainly would not have had the measure of success we achieved without the assistance of your Bureau and staff."

Two sprays on marginal areas may give adequate grasshopper control in wheat

Twenty square miles of farmland in western Kansas were used in an experiment to determine means of protecting newly sprouted fall-seeded wheat from the second generation of the lesser migratory grasshopper.

From May 24 to 31, 1952, 285 acres of infestation, of first-generation grasshoppers numbering 25 to 500 per square yard were sprayed with aldrin at the rate of 2.5 ounces per acre, with a ground sprayer. The sprayed area comprised the margins of the wheat fields. As a result, populations were reduced to less than 1 per square yard. The residual action of the spray lasted 1 month and killed many adults which had moved into the treated margins from field infestations missed by the sprayer. A second treatment was necessary. On July 2, 250 acres of margins were sprayed by plane with aldrin at the rate of 4 ounces per acre. Populations which numbered 10 to 20 per square yard were reduced to 1 to 3 per square yard. Two sprayings to wipe out the first-generation infestation may well be the way to control grasshoppers in the winter-wheat areas of western Kansas.

Grasshopper diseases identified

With the assistance of personnel doing research on insect diseases at the University of California and in Science Service, Canada Department of Agriculture, several diseases of grasshoppers were identified. The fungus *Empusa grylli* is at present the most widespread and destructive disease in Montana. It has been found infecting grasshoppers as early as the second instar. Another disease, *Nosema* sp., was found for the first time under field conditions in northern Montana. In 1950 this disease was cultured from grasshoppers collected in the vicinity of the Bozeman, Mont., laboratory. So far as known these are the only records of *Nosema* in grasshoppers. A protozoan disease *Malemba locustae* has infected grasshoppers under laboratory conditions.

Good initial grasshopper kills obtained with several insecticides

Emulsions and solutions of aldrin were about equally effective for grasshopper control in field tests on 1¼-acre plots of alfalfa at Tempe, Ariz. Dosages of ½, 1, 2, and 4 ounces of aldrin and ½ and 2 ounces of dieldrin per acre were used. These insecticides were slightly more effective in short, than in tall, dense alfalfa. They gave about equal control in green and dry alfalfa. Kill from contact action alone was 60 percent as high, and from ingestion 75 percent as high, as from contact and ingestion combined. The peak grasshopper reduction was usually reached within 3 days, but with dieldrin or the higher dosages of aldrin there was some residual effect for 10 days or longer.

Heptachlor at either 2 or 3 ounces per acre was effective in controlling grasshoppers in alfalfa under conditions which prevailed early in 1952 in Arizona. In seven replicated tests of emulsion sprays this insecticide at 2 ounces per acre gave an average kill of 92 percent. At 3 ounces per acre the kill was 96 percent. EPN at 6 ounces per acre gave an average kill of 90 percent; at 2 ounces only 61 percent.

A 60-percent aldrin nonemulsifiable preparation was tested in water mixtures at spray temperatures of 50°, 75°, and 100° F. At the recommended rate of 2 ounces of aldrin per acre, the 100° spray gave an average kill of 81 percent. The cooler sprays gave 53- and 51- percent kills.

Mormon Cricket Control

Mormon crickets controlled in five western States

During 1953 more than a half-million acres in five States were baited to control a Mormon cricket outbreak threatening several million adjacent acres. This was the third year of a typical Mormon cricket buildup. Poisoned bait distributed from mid-April through June in Nevada, California, Utah, Idaho, and Colorado halted the biggest outbreak of these insects that has occurred since 1940. Control efforts were carried out cooperatively with Federal land-managing agencies, States, counties, communities, and organized groups of individual ranchers. New insecticidal materials—mostly aldrin in steam-rolled wheat—and rapid methods of bait distribution with aircraft and modern ground equipment made it possible to achieve excellent kills within a few hours after treatment. The 1953 control work prevented crop damage, stopped migrations, delayed and possibly prevented a potential major Mormon cricket outbreak.

Three new toxicants tested in Mormon cricket bait

Preliminary field tests in Nevada with three new insecticides as toxicants in poisoned bait for Mormon cricket control showed that 2 ounces of aldrin, 1 ounce of dieldrin, or 4 ounces of heptachlor were as effective as either toxaphene at 1 pound, or chlordane at ½ pound, per 100 pounds of carrier.

Cutworms

In experimental work, four insecticides have given practically complete control of cutworms in wheat. These are DDT at 1 pound, dieldrin at 0.2 pound, endrin at 0.27 pound, and CS–708 at 1 pound per acre. BHC and parathion gave very poor control. Toxaphene at 2 pounds per acre gave slightly better than 90-percent control.

Cooperative Work With Wheat Develops Hessian Fly-Resistant Strains

Twenty-four soft and hard red winter wheats, including the outstanding hessian fly-resistant strains resulting from breeding work conducted in cooperation with the Bureau of Plant Industry, Soils and Agricultural Engineering and State agricultural experiment stations, were tested in uniform nurseries at several agricultural experiment stations. Derivatives of W38, Marquillo, P. I. 94587, and Ribeiro showed no or low hessian fly infestations as compared with from 20- to 85-percent infestation in susceptible checks.

Insecticides Tested Against Corn Earworm

In tests of various insecticides conducted in Texas, Illinois, and Indiana, DDT at 0.5- to 0.75-percent strength, heptachlor or dieldrin

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at 0.75-percent, or endrin at 0.2-percent strength in emulsions containing mineral oil gave the most effective earworm control. TDE was less certain in emulsions but was satisfactory in oil solutions. Tests to determine the absence of harmful residues are necessary before heptachlor, dieldrin, or endrin can be recommended.

Resistance of Corn to Corn Earworm

Nine of the most corn earworm-resistant new hybrid sweet corns tested in 1952 had inbred LTB as one parent. This inbred in crosses produces a long, slender ear such as is desired by the southern fresh corn shipper. No other hybrids from outside sources showed much promise. Several sweet corn crosses from current breeding material continued to be resistant. Crosses containing inbred 20 were especially good. This inbred is perhaps the best yellow sweet corn found to date for breeding for corn earworm resistance.

Twenty of the most promising dent corn hybrids and two open-pollinated varieties were tested at the Mississippi Agricultural Experiment Station, State College, Miss., and at five of its branch stations. Ten of the strains showed some resistance. At Poplarville, the hybrids Ga. 281 and Miss. 2115 proved highly resistant to both the corn earworm and rice weevil. Dixie 18, Miss. 2117, Miss. 1216, Coker 811, Miss. 1212, Dixie 11, and La. 521 were only lightly damaged by the corn earworm and moderately damaged by the rice weevil. Dixie 18 was resistant to the earworm at State College and Verona. Dixie 11, Coker 811, and Funk G875W were moderately resistant at Verona. Coker 811 had slightly more damage than Dixie 18 at State College but showed some resistance to the earworm, along with Dixie 11 and Funk G875W.

The resistance work was done in cooperation with plant breeders of the Bureau of Plant Industry, Soils, and Agricultural Engineering and the agricultural experiment stations of Illinois, Indiana, Texas, Iowa, Ohio, Mississippi, and South Carolina.

European Corn Borer Research

Corn strains tested for corn borer resistance

At the Bureau's Toledo, Ohio, station a uniform single cross comparison of parent lines furnished by agricultural experiment stations in the northern States of the North-Central region showed inbreds Michigan 1334 and Minnesota A498 to have a good degree of resistance to first brood infestation.

Possibilities of combining in the same line resistance to both the northern corn rootworm and the European corn borer were studied at Ankeny, Iowa. It was found that B14, B2, and 38–11 and related lines were outstanding in contributing rootworm resistance.

The resistance investigations were conducted in cooperation with corn breeders in the Bureau of Plant Industry, Soils, and Agricultural Engineering and the State agricultural experiment stations.

New insecticides effective against corn borer

Field tests of five new insecticides, each applied at the rate of 10 gallons of spray per acre, showed that two of them were equally outstanding in effectiveness and gave as high control as DDT, the currently recommended insecticide for corn borer control. These

were EPN, at 0.5 pound per acre, and endrin at 0.4 pound per acre. CS–708 and heptachlor at 1 pound per acre, although matching each other in their effectiveness, were inferior to EPN and endrin. Isodrin at 0.4 pound per acre was better than the untreated check but was inferior to the other insecticides compared in this experiment.

Parasites aid in control of European corn borer

An additional 30,000 parasites of the European corn borer, comprising six introduced species, were released in Maryland and Minnesota, in a cooperative undertaking with these States.

During a 7-year period in most of Connecticut and Massachusetts and all of Rhode Island, an average of 24 percent of the overwintering borers have been parasitized. *Macrocentrus gifuensis*, an imported wasplike parasite, was chiefly responsible. Over a 5-year period in other eastern States the introduced fly *Lydella stabulans grisescens* was the most important parasite of the borer. Parasitization by this fly in fall collections averaged 23 percent throughout New Jersey, 22 in Delaware, 27 in northern Maryland, 26 on the Eastern Shore of Maryland, and 15 in the Tidewater area of Virginia. Parasitization by *Lydella* in 1951 amounted to 28 percent in southwestern Ohio, 12 percent in west central Ohio, and ranged from 25 to 43 percent in five districts in Illinois. In Iowa in 1951 no introduced species were recovered in two western districts, but a maximum of 45-percent *Lydella* parasitization occurred in one eastern district in that State.

A protozoan disease, *Perezia pyraustae*, was studied in cooperation with the Iowa Agricultural Experiment Station. This disease was found to be widespread in the Corn Belt. It proved to be highly pathogenic to the corn borer in laboratory studies.

Insect-Proof Selfing Bag Benefits Sorghum Breeders

For the benefit of sorghum breeders, work was continued in 1952 to improve methods of insect-proofing bags that are placed over sorghum heads to prevent cross pollination. A 25-percent aldrin emulsifiable concentrate applied in a streak approximately ½ inch wide by 4 inches long on the inside of the selfing bags, at the rate of 72 mg. of actual aldrin per bag, effectively controls corn leaf aphids and corn earworms on sorghum heads inside the bags. The Oklahoma Agricultural Experiment Station and a commercial paper company have cooperated in producing at the factory at least 100,000 of these treated selfing bags. These were for use by sorghum breeders and certified seed producers during 1953. Previously, all such bags have been treated manually.

Entomologists Test Cereal Grains for Resistance to Greenbugs

Apparent high resistance to greenbug attack was found in Dickinson No. 485 C. I. 3207, a variety of durum wheat. This variety is being tested more thoroughly in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Oklahoma and Texas Agricultural Experiment Stations. Two hundred durum wheats and 200 wheats of Chinese origin were tested under greenhouse conditions at Stillwater, Okla., and Denton, Tex. Two other varieties of durum, Kubanka, C. I. 2094 and C. I. 1354, appear to be very

resistant to greenbugs when the aphids are allowed to build up gradually. Both varieties are very susceptible to a sudden heavy greenbug infestation. Several other varieties appear to be unfavorable for greenbug reproduction. For example, greenbugs reproduced three times as fast on Pawnee as on Mahmoudi C. I. 2099.

Field tests were made of 20 varieties of oats, 24 varieties of barley, and 28 varieties of wheat that had shown some greenbug resistance under greenhouse conditions. All barley varieties showed a high degree of resistance. Kearney C. I. 7580 and unnamed C. I. 4240–2 appeared to be more resistant than Omugi barley. Andrew, Bond × Rainbow Sel., and a Clinton × Ventura selection were among the most resistant oat varieties tested.

Cultural and Insecticidal Controls Effective Against Brown Wheat Mite

Tillage experiments to determine the effect of different cultural practices on the brown wheat mite (*Petrobia latens*) gave a 95-percent reduction in the numbers of newly hatched mites when the eggs were buried to a depth of one inch, and 97 percent when buried at 2½- and 5-inch depths. Eggs used in the experiments were extracted from samples of wheat stubble and soil by means of a specially designed apparatus. The susceptibility to cultural controls of newly hatched mites may prove useful in further control experiments.

Various chemical formulations were also tested in southwestern Kansas against this mite. Airplane application of ½ pound of parathion per acre was required for control of the mite. None of the new specific miticides showed outstanding performance against the mite when applied at recommended dosages or even at doubled dosages. Against adult mites Systox at ¼ pound per acre was about as effective as parathion at ½ pound. Parathion at ¼ pound was more effective than Metacide at ½ pound per acre. One-half pound of schradan per acre was next in effectiveness. Emulsions were much less effective than solutions in aerial sprays. Used in ground equipment, emulsions were slightly more effective than suspensions, and the flat type nozzle as efficient as the cone type. The latter observation is of considerable importance, since many farmers are equipped with flat type nozzles for use in weed control.

This work on the brown wheat mite was conducted in cooperation with the Kansas Agricultural Experiment Station.

Four Insect Vectors May Be Involved in Transmission of Wheat Yellow Streak Mosaic

Possible instances of transmission of wheat yellow streak mosaic by insects were obtained with 3 of 27 species studied in greenhouse tests in 1952. The species involved were the wheat stem maggot *Meromyza americana;* flea beetles of the family *Phalacridae;* and the leafhopper *Endria inimica.* About 3,000 insects were used in the 250 experiments performed during the year.

Early in 1953, following information received from J. T. Slykhuis, Science Service, Canada Department of Agriculture, Lethbridge, Alberta, Canada, that he had transmitted the mosaic with the erio-

phyid mite *Aceria tulipae*, 45 laboratory tests were made using this mite. Thirty-seven of these tests resulted in transmission of the disease. In view of this finding and the possibility of contamination of greenhouse tests by this extremely small mite, it is now thought that at least some of the earlier transmissions may have resulted from the mites rather than the wheat stem maggots, flea beetles, or leafhoppers.

This work was conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Kansas Agricultural Experiment Station.

Practical Control Measures Sought for Legume Pests

Excellent kill of exceedingly heavy populations of the potato leafhopper on alfalfa in Maryland was obtained at the recommended dosage of ½ pound of methoxychlor in 5 gallons of emulsion spray per acre. Comparable tests with 1 to 1½ pints of malathion per acre gave very effective kill, but the residual effect was inadequate. Chemists found no residues of malathion on samples of sprayed alfalfa collected 7 days after treatment.

Application on April 4 of 0.27 pound of dieldrin per acre reduced meadow spittlebug populations in Maryand by an average of 66 percent on alfalfa and 89 percent on red clover. The reduction persisted through May 23.

Alfalfa weevil adults were controlled in the early spring in Utah with heptachlor at 4 ounces per acre. This insecticide was as effective as chlordane at 1.5 pounds or dieldrin at 4 ounces per acre, the dosages now recommended. The use of 8, 13, or 26 gallons of spray per acre did not influence the kill of adults or the later populations of larvae. Chemists found no more than a trace of insecticidal residue on samples of hay taken from the heptachlor-treated plots just before harvest.

Better than 98-percent control of alfalfa weevil larvae was obtained with acre dosages of 1 ounce of either heptachlor or dieldrin, 2 ounces of aldrin or endrin, or 8 ounces of chlordane. Further information on possible harmful residues will be obtained before any of these are recommended.

Heptachlor gave promising results in controlling lygus bug nymphs in seed alfalfa in Utah. A 95-percent control for 19 days was obtained with 4 ounces per acre applied when the plants were in the bud stage. This compared to 98-percent control through the use of the recommended treatment of 1.5 pounds of DDT. In the same experiment endrin and isodrin at 0.2 pound per acre gave only 82- and 75-percent control of lygus bugs but gave excellent control of small populations of the pea aphid. Initial field tests were made in Utah to determine the toxicity to honey bees of several insecticides that are effective against alfalfa pests. Their relative toxicity to bees determines their utility for application to seed alfalfa in bloom. Four ounces of heptachlor, 10 ounces of malathion, or 4 ounces of TEPP per acre, applied in water-emulsion sprays in the early morning before the bees began visiting the field, killed too many bees to justify application during the bloom period. An early morning application of aldrin at 2 ounces per acre, or an evening application of TEPP at 4 ounces per acre was reasonably nontoxic to bees.

Alfalfa Selections Excel in Resistance to Pea Aphid

Twenty-four alfalfa plants 100-percent resistant to the pea aphid were screened from 958 new accessions tested in the greenhouse in cooperation with plant breeders of the Bureau of Plant Industry, Soils, and Agricultural Engineering and the California Agricultural Experiment Station. Of the resistant strains, 7 trace to the variety Ladak, 6 to Ranger, 5 to California Common, 5 to Argentine, and 1 to Chilean. Four plants of each of 145 clones of F_1 crosses, together with 4 plants each of 6 susceptible clones for checks, were transferred to the field at the California field station near Lancaster for testing under conditions of severe pea aphid attack which normally occurs there.

Sugarcane Borer Infestations Reduced by Use of Resistant Varieties

Two sugarcane plantations in Florida reduced their sugarcane-borer population by one-half by replacing borer susceptible varieties F. 31-436 and Co. 290 with resistant varieties F. 31–962 and C. P. 34–79. In Florida varietal test plots, F. 31–962 had only 2 percent of the joints bored compared with 15 for another commercial variety and 12, 10, 8, and 5 each for 4 unreleased varieties.

Introduced Sugarcane Borer Parasites Released

Nearly 5,800 individuals of the sugarcane borer egg parasite *Prophanurus alecto* were released in Louisiana sugarcane fields during August and September 1952. Of these, 2,119 were reared from six shipments of this species received from Trinidad. This number was increased by breeding at the Houma, La., station. Although this parasite was seen ovipositing in borer egg clusters, no field recoveries have been made.

Fifty *Agathis stigmaterus*, a larval parasite of the sugarcane borer, and 500 *Agathis texanus*, a larval parasite of the ramie leafroller, were received at the Houma station from the Belle Glade, Fla., station. *A. stigmaterus* parasitizes about 8 percent of the sugarcane borers in Florida and is capable of overwintering in Louisiana. This parasite was successfully reared at the Houma station in 1952. Eighteen *stigmaterus* and 266 *texanus* parasites were released in sugarcane fields in Louisiana in August and September.

Start Made Toward Biological Control of Wheat Stem Sawfly

Two parasites of the wheat stem sawfly introduced from Europe, *Bracon terebella* and *Collyria calcitrator*, numbering 2,131 and 692, respectively, were released at Minot, N. Dak. and Choteau, Mont., in areas where the sawfly is causing economic damage. A newly described native parasite, *Bracon lissogaster*, was collected at Choteau. *B. cephi*, another native sawfly parasite, has one complete and a partial second generation at Minot.

Physiological Resistance to Wheat Stem Sawfly Apparent in One Wheat Variety

Entomologists studying a large number of wheat varieties for their resistance to the wheat stem sawfly have at last found a completely hollow-stemmed wheat, P. I. 170924, that appears to possess a physiological type of resistance. All other resistant varieties observed have solid stems. Resistant varieties are used by plant breeders in the wheat-improvement program. The work was done in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Montana and North Dakota Agricultural Experiment Stations. Rescue, a Canadian, solid-stemmed, resistant spring wheat, was used as a resistant check in all tests.

TRUCK-CROP AND GARDEN INSECTS

Potato Psyllids Traced to Southern Breeding Grounds

Eight years of ecological studies have at last tracked down the breeding grounds of the potato psyllid. This species is the cause of the destructive psyllid yellows disease of potatoes and tomatoes. Heavy infestations of this insect in the Rocky Mountain States have been traced to psyllids that overwinter and breed in the spring in southern New Mexico and southwestern Texas. These studies have shown that psyllid outbreaks in the potato- and tomato-growing areas in Colorado, Wyoming, and Nebraska depend on the spring development of huge numbers of psyllids in southwestern Texas and New Mexico and favorable weather during their northward migration. In years when spring populations in the southern States were light, outbreaks did not occur in the northern potato-growing areas. When spring populations in the south were high, outbreaks occurred in the northern areas if weather conditions were favorable during May and June.

Sweetpotato Weevil Control

By the end of 1952 the sweetpotato weevil had apparently been eradicated from 14,928 farm property units, including 45 entire counties in the 7 southeastern States of Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. Weevil infestations of 26 percent in commercial producing acreages in Louisiana have been reduced to 2 percent and losses reduced from approximately $3 million in 1946 to an estimated $228 thousand in 1952.

Owing to the effectiveness of the 1952 program, planting restrictions were removed from 1,595 farm units formerly infested. Four formerly infested counties were declared free from infestation. The number of infested properties in 54 counties of the 6 States comprising the eradication area was reduced from 3,522 to 3,191.

During the year cooperating States contributed about 70 percent of the total cost of the control program. In addition, sweetpotato growers, processors, and shippers in the control area purchased and applied insecticides and fumigants in the amount of $50,000.

Several Insecticides Effective in Controlling Sugar-Beet Root Maggot

Tests were conducted in Idaho, to compare the relative effectiveness of several insecticides and a soil fumigant for control of the sugar-beet root maggot on sugar beets. Insecticides tested were aldrin, dieldrin, and heptachlor. All treatments, except soil fumigation with ethylene dibromide, gave increases in yield over the check. Treatment of sugar-beet seed with heptachlor at the rate of ½ pound of toxicant per 100 pounds of seed increased the yield 1.65 tons per acre over the check. Aldrin, dieldrin, and heptachlor, at the rate of 3 pounds per acre in a fertilizer mix, applied as a broadcast, preplanting soil treatment, gave increased yields over the checks of 2.28, 1.97, and 1.08 tons, respectively, per acre. When dieldrin and heptachlor were mixed with a fertilizer and applied at the rate of 1 pound per acre in the furrow at planting time, there were increased per-acre yields of 1.62 and 2.09 tons, respectively, over the check.

Experiments Concluded on Effects of Insecticides on Tobacco Rotations

Dieldrin was added in 1952 to the series of experiments initiated at Florence, S. C., in 1947 to determine the effects of accumulations of DDT, BHC, and toxaphene in the soil on tobacco and crops usually rotated with it. These experiments have provided much useful information regarding the fate of these materials in the soil, as well as their phytotoxic effect. Further soil applications of these insecticides were discontinued at the end of the 1952 season. Soil samples will be taken from the plots for the next two years in order to obtain further information on the persistence of the insectides. These experiments were in cooperation with the South Carolina Agricultural Experiment Station and the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Residual Effects of Insecticides on Subsequent Tobacco Crops Studied

Effects of various insecticides on subsequent crops of tobacco grown in the same 1/50-acre plots are being studied in a new series of experiments initiated in 1953 at Florence, S. C., in cooperation with the South Carolina Agricultural Experiment Station and the Bureau of Plant Industry, Soils and Agricultural Engineering. Cotton grown on one series of plots will be treated with the insecticides that are now recommended for the control of cotton pests or that show promise for use on that crop. Materials to be included in these tests are isodrin, endrin, methyl parathion, Systox, toxaphene, BHC, aldrin, dieldrin, heptachlor, chlordane, and EPN. These 11 materials will be applied as dusts and sprays in approximately the dosages that would normally be applied to control insects on cotton. Tobacco will be planted on these same plots in 1954. Following harvest, the tobacco will be cured and samples supplied to leading cigarette manufacturers for flavor and aroma determinations, and possibly to Bureau chemists or insecticide manufacturers for residue analyses. Results of these plot tests will not be available until 1954. A second series of 1/50-

acre plots received the same dosages of the respective insecticides in the spring of 1953. Tobacco was planted in these plots in order to obtain advance information on the possible effect of the insecticides on the cured tobacco.

Parathion Drench Controls Green June Beetle in Tobacco Beds

Previous findings that a drench containing parathion is quite effective against larvae of the green June beetle were substantiated in further experiments in South Carolina. Drenches containing lindane wettable powder or an emulsifiable concentrate of CS–708 were fairly effective, although less so than parathion. Drenches containing aldrin, dieldrin, EPN, and malathion were of little value. Poisoned baits containing parathion or mythyl parathion were as effective as baits containing fluosilicates, now recommended for the control of these larvae. Baits containing lindane and dieldrin were less effective.

Replicated tests with five insecticides were made in Tennessee, where green June beetle larvae were more abundant than usual in 1952. These tests showed that tobacco in plant beds can be protected from these larvae with parathion drench 0.5 percent, malathion drench 1 percent, or parathion dust 1 percent. Each drench was applied at the rate of 100 gallons per 100 square yards. Aldrin dust 4 percent and dieldrin dust 4 percent were only moderately effective.

TDE Recommended for Control of Hornworms on Tobacco

Experiments in North and South Carolina, Tennessee, and Florida showed TDE to be the most effective of the available insecticides that can be used for control of tobacco and tomato hornworms on tobacco. Tests by several tobacco companies showed that the flavor and aroma of cigarettes made from tobacco treated with TDE were not adversely affected. Residue analyses of the cured tobacco revealed the presence of only relatively small quantities of the insecticide. TDE was therefore recommended for control of hornworms in tobacco in a leaflet published in January 1953.

Laboratory toxicity tests in North Carolina disclosed that TDE was as toxic to tobacco hornworm larvae as toxaphene, and that it was slightly more repellent to the larvae. In these tests CS–674A (Bulan) had about the same degree of toxicity to hornworm larvae as CS–708. The latter, in turn, was slightly less toxic than CS–728. CS–728 was considerably more toxic than TDE and both CS–674A and CS–728 were quicker in killing action than TDE. EPN was extremely toxic to hornworm larvae and functioned as both a contact and stomach poison.

Experiments have shown endrin to be the most effective insecticide tested thus far for the control of hornworms or associated infestations of hornworms and budworms. Its effect on the flavor and aroma of the cured and manufactured tobacco, as well as possible health hazards involved in its use, are being investigated. Tests in South Carolina showed 0.6 pound of endrin per acre was more effective and killed hornworms quicker than 1 pound of TDE, CS–708, or CS–728.

DMC Promising for Cyclamen Mite Control on Some Greenhouse Plants

DMC emulsion was the most effective material tested against the cyclamen mite on plants outdoors and under glass in New York where fumigation or hot-water treatments are impractical. On field-grown delphinium on Long Island, DMC caused no injury and gave good control of a limited infestation and moderate control of a heavy infestation of cyclamen mite. Laboratory tests with 20 materials showed DMC emulsion to be the most effective material against this mite on ivy. Plant tolerance to DMC was not entirely satisfactory. Kalanchoes were consistently injured and African violets and ivy were sometimes injured. Injury to African violets was reduced when a spreader was included. Soil or foliage applications of schradan and Systox for cyclamen mite control on gerbera in the greenhouse were not promising.

Multipurpose Dust Mix for Roses Sought

A comparison of 30 dusts was made in small field plots at Beltsville, Md., in an attempt to develop a multipurpose dust mixture for roses The best growth resulted when a mixture of ferbam, sulfur, lindane, DDT, and 88R was applied. None of the mixtures tested controlled flower thrips, Japanese beetles, or mildew. They did give good control of black spot.

Develop Soaking Treatments for Tulip Bulb Aphid

As little as 1 ounce of 25-percent lindane per 100 gallons of water gave complete kill of all tulip bulb aphids contacted, and 1 ounce of 15-percent parathion gave 100 percent dead and moribund aphids in limited trials of soaks on Long Island. Gladiolus corms grown to maturity after soaking in preparations of BHC, lindane, or parathion, stronger than required for control of tulip bulb aphid, showed no adverse effect on plant growth or flower, corm, or cormel production.

Chlordane Soil Treatment Prevents Ant Reinfestation for Several Weeks

Further investigations in Maryland on the control of ants affecting ornamental plants and ornamental gardens corroborated results in preceding years that showed applications of chlordane sprays, made from wettable powder, to the surface of ant-infested soil, followed by a thorough drenching of the treated area with water, killed a high percentage of the ants and prevented reinfestation for a period of several weeks. Use of 4 ounces of 50-percent chlordane wettable powder in 100 gallons of water to each 1,000 square feet of soil surface gave best results. Research on this problem has been discontinued.

Several Treatments Give Satisfactory Narcissus Bulb Fly Control

Tests in Washington with preplanting soaks of narcissus bulbs in dilutions of chlordane, aldrin, or heptachlor demonstrated that these materials will give practically complete protection from attack by

larvae of the narcissus bulb fly. With each of the three materials, a soaking period of not more than 10 minutes proved satisfactory. Other tests indicated that dieldrin may also be effective for this purpose. Less satisfactory results were obtained with lindane. DDT and toxaphene were ineffective when used in this manner. Large-scale tests with chlordane soaks by growers indicated that there may be some factors which affect the efficiency of this material in controlling the bulb fly, since the results were variable.

Quick Kill of Mexican Bean Beetles Obtained With Several Insecticides

Malathion proved quite effective in giving a quick kill of moderate to heavy infestations of Mexican bean beetle adults that were causing severe injury to young beans in an experiment conducted in cooperation with the North Carolina Agricultural Experiment Station. Parathion, methoxychlor, rotenone, isodrin, and CS–708 also gave good protection.

Insecticides Control Cabbage Aphid

Dusts containing TEPP or parathion gave good control of the cabbage aphid when applied by cabbage growers in South Carolina during 1952. In contrast to the previous year's results, no rapid rebounds in aphid populations developed in commercial fields after an application of either of these insecticides. The infestations gradually decreased in all fields under observation and ceased to be a menace before harvest began. Systox and a freshly prepared TEPP dust were the most effective materials used in field-plot experiments, the former showing much longer residual effects. Residue analyses by the manufacturer showed no Systox in headed cabbage taken from the plots 8 weeks after application. Further studies are necessary, however, to determine whether or not there may be any health hazard from possible breakdown products of Systox not revealed by present known methods of chemical analysis. A parathion dust and TEPP, lindane, schradan, and nicotine-soap sprays gave an immediate degree of aphid control. Dieldrin and endrin had no apparent effect on the aphids. Insect enemies of the cabbage aphid were more abundant, and rainfall was higher in 1952 than in the preceding crop season.

Recommended Procedures Reduce Pickleworm Injury

Widespread use since 1950 of insecticides, notably lindane, has appreciably reduced general populations of the pickleworm and of associated melonworm and melon aphid infestations in South Carolina. In the Charleston area the pickleworm did not appear in 1952 until the middle of May and did not cause serious injury to spring-grown cucurbits. Moderate to heavy infestations developed during the summer and fall. In general, these were lower than in preceding years.

Treatments for Onion Maggots Increase Onion Seed Yields

In an experiment in Idaho to work out a control for the onion maggot on onions grown for seed, several insecticides were applied to the rows as soil-surface treatments. The applications were timed

to coincide with emergence of the adult. Aldrin, chlordane, DDT, dieldrin, heptachlor, and toxaphene were applied at the rate of 1 pound, and lindane at ½ pound of toxicant in 25 gallons of water per acre. The average yields of seed per acre for the two best treatments were 697 and 627 pounds for dieldrin and heptachlor, as compared to 442 pounds for the checks. It was estimated that, after deducting the cost of the insecticides and their application, there were net profits of $184 and $133 per acre, respectively, for the dieldrin and heptachlor treatments.

When onion bulbs were soaked for 15 hours in a 0.1-percent emulsion prior to planting, the average yields of seed per acre for chlordane, heptachlor, and Systox treatments were 819, 715, and 708 pounds, respectively, as compared to 564 pounds for the check.

New Insecticides Evaluated for Pea Aphid and Pea Weevil Control

Various new insecticides were evaluated for control of the pea aphid in experiments continued in Washington, Idaho, and Oregon. Metacide in a spray was superior to parathion at the same dosage for control of the pea aphid, and was less dangerous to apply. Malathion as a spray at 2½ times the strength of parathion, and a commercially prepared safened parathion at the same strength were approximately equal in effectiveness to parathion spray.

A series of tests for pea weevil control showed that none of the insecticides with a low potential in residue hazard exceeded DDT in effectiveness.

Green Peach Aphids Show Signs of Insecticide Resistance

Green peach aphids on potatoes in Washington may be developing some resistance to insecticides. Field experiments there to develop methods of controlling these aphids, and indirectly to retard the spread of leaf roll and other virus diseases carried by them, have since 1948 shown the decreasing effectiveness of DDT as a means of control.

In experiments on early crop potatoes excellent control was obtained in 1952 with DDT-parathion-sulfur dusts, DDT-parathion emulsion sprays, and malathion emulsion sprays. Neither DDT dusts nor DDT-oil sprays gave satisfactory control. On late crop potatoes none of these insecticides or TEPP dust gave satisfactory control, although the dosages were increased to two or three times the usual amount.

Further Studies Needed on Systox as Potato Aphid Control

Systox will control four species of aphids affecting potatoes in Maine, field experiments there have disclosed. Systox was applied weekly in spray mixtures to foliage of the growing plants as well as in the furrow just before planting the potato seed pieces. Very small quantities of the insecticide were sufficient, the minimum total-season amounts of active ingredient being 0.78 pound per acre when applied to the plants and 0.375 pound in the furrow. Better control of aphids, particularly the potato aphid, was obtained by stopping weekly applications of DDT about August 1 and using one or two applications of Systox, parathion, or malathion than by continuing with DDT

throughout the remainder of the season. Systox controlled the aphids so well that only a single application was necessary. Two applications were required of either parathion or malathion. Systox is not, however, recommended for use on potatoes, because further studies are necessary to determine whether or not there may be any hazard from residues of this material or its breakdown products due to translocation to the tubers.

Wireworm Control Effective for Several Years

Soil treatments with DDT at 10 pounds per acre of the active ingredient will control wireworms and remain effective for as long as 6 years, investigations in California have shown. Fumigation with ethlyene dibromide will also control wireworms immediately, but gives no lasting effect. In experiments heptachlor, dieldrin, aldrin, endrin, and chlordane showed promise of being as effective as DDT for wireworm control. Most of these materials were more effective when applied 60 days before planting than when applied 20 days before planting. Lima beans grown in soil treated with four annual applications of 20 pounds of chlordane, 20 pounds of toxaphene, 4 pounds of aldrin, or 3 gallons of ethylene dibromide per acre were not affected as to yield or flavor. The flavor appraisals were made by an experience taste panel of the Bureau of Agricultural and Industrial Chemistry at Albany, Calif.

Field experiments in Washington have shown that DDT as a contact insecticide in the soil will control wireworms for as long as 8 years. At least 30,000 acres of the worst wireworm-infested lands, devoted to the growing of truck crops in the Pacific Northwest, have now been treated at the rate of 10 pounds of DDT per acre.

Research during 1952 to develop methods for controlling wireworms in potatoes in South Carolina showed that aldrin, dieldrin, and heptachlor gave adequate wireworm control when applied to the soil at 1 and 2 pounds per acre shortly before potatoes were planted. Slightly less effective results were obtained with 2 and 4 pounds of chlordane. No differences between several methods of applying aldrin and chlordane were found. Chemical analyses and bioassay studies made by Bureau chemists and representatives of the insecticide industry showed no significant quantities of insecticide residues in tubers grown in soils receiving the maximum dosages of the four materals.

Improved Feeder Devised for Duster

An improved feed and metering device for a ground duster was constructed and installed in Oregon in cooperation with engineers of the Bureau of Plant Industry, Soils, and Agricultural Engineering. These improvements reduced difficulties previously experienced in obtaining the desired uniform rate of dust discharge under varying conditions of temperature and humidity.

Spray Equipment Evaluated for Pea Aphid Control

Observations of equipment performance were made in connection with a series of ground spray applications of miscellaneous insecticides

for the control of pea aphids on peas in the Blue Mountain area of Oregon and Washington. The tests also involved applications of the systemic insecticide Systox and parathion against pea aphids. The equipment used gave consistent and predictable rates of insecticide application.

Complex Airplane Spray Distribution Patterns Confirmed

Further research on airplane spray-distribution patterns at low flight elevations, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering in the Pacific Northwest, confirmed and extended the findings of previous years. These and earlier studies show that spray deposits from low-flying aircraft vary greatly in any one flight, both laterally (across) and longitudinally (along) the line of flight. The variations primarily result from aerodynamic forces generated by the flight of the plane.

These findings indicate that spray patterns may be significantly modified and improved by changing the spacing of nozzles, and the use, within the zone affected by the propeller slipstream, of fine sprays inboard in combination with coarser sprays outboard.

A high-lift Stearman airplane with square wing tips showed few differences so far as basic spray patterns are concerned, except that spray caught in the wing-tip vortices is not carried so high as with the stock Stearman. With identical nozzle arrangements, there was apparently a wider effective swath with the high-lift plane.

In general, tests with aerial applications of dusts bear out previous findings that it is extermely difficult to obtain consistent results and that thermal action is probably a factor more adverse than surface winds.

Aerial Spray Application Controls Black Bean Aphid

An aerial spray application of very fine atomization, with 1.8 pounds of nicotine alkaloid per acre gave about 80-percent control of the bean aphid on trellised beans in the Willamette Valley of Oregon. This degree of control is considered satisfactory. Aerial spray applications of 0.4 pound of TEPP and an aerial dust application of 1.7 pounds of nicotine alkaloid per acre were ineffective in controlling this insect.

Washes Tested for Removing Insects From Harvested Vegetables

About 80 formulations were tested at Beltsville, Md., in a search for a wash that may be used in processing plants to remove aphids from harvested kale. Twelve of the formulations tested removed more than 90 percent of the aphids. There was no visible injury to the kale 24 hours after washing. All of the promising formulations contain 1 percent of Energine in combination with one of several different emulsifying or wetting agents.

Another 80 formulations were tested at Beltsville as washes for the removal of asparagus beetle eggs from asparagus. Nine of them removed more than 89 percent of the eggs without causing more than a trace of visible injury to asparagus at the end of 24 hours. The more promising washes contained 0.5 percent of toluene plus 2 percent

of deodorized kerosene with an emulsifying agent, or 0.25 percent of toluene plus 1.25 or 1 percent of deodorized kerosene also with an emulsifying agent. Taste tests by the University of Maryland on canned and frozen asparagus that had been washed in four of the more promising formulations showed that each had caused a significant off-flavor.

FRUIT AND NUT INSECTS

Citrus Blackfly Eradication in Mexico

Cooperative citrus blackfly survey and control work continue in Mexico

There was additional spread of the citrus blackfly throughout the Republic of Mexico during 1952. At the end of 1952 this insect had reached every citrus fruit growing area in the Republic. In most areas the fly has become well established. Elsewhere incipient infestations exist, which have been prevented from developing by aggressive spray campaigns, particularly in the area close to the International Border.

Accidentally introduced into Mexico about 1935, the citrus blackfly has spread rapidly from its point of introduction on the west coast of Mexico. Its damaging effects can be seen throughout the country wherever citrus is grown commercially. Survey work in Mexico is conducted to detect infestations that may develop along the International Border. Where such infestations are discovered, control work is undertaken to prevent them from building up to a point where they would endanger American citrus-fruit production. This work is done in cooperation with the Mexican Department of Agriculture and the local agricultural committees.

Citrus blackfly infestations are difficult to find when populations are low. Trees must be inspected almost leaf by leaf. It frequently requires 30 minutes or more to thoroughly examine a normal-sized citrus tree. During the past year Mexican Nationals, working under the direction of Bureau supervisory employees, inspected more than 34,000 properties for blackflies. Many of these were dooryard plantings. Trees inspected exceeded 217,000 and 242 blackfly infestations were discovered, all of them potentially dangerous to American citrus production. These were immediately sprayed by Mexican authorities. The Mexican National Blackfly Committee, in addition to its spray campaign, is actively engaged in establishing parasites wherever the blackfly has become so widespread as to make its eradication improbable.

Surveys were made in the Lower Rio Grande Valley of Texas during 1952. Inspections were made in all towns and along the principal highways in the citrus growing area of the Valley. Trees on more than 5,000 properties were closely examined without finding any blackfly infestation.

Large-scale citrus blackfly eradication campaign in northern Mexico

The eradication of an infestation found in Matamoros, just across the river from Brownsville, Tex., and not far from the large Texas citrus plantings in the Lower Rio Grande Valley, became the most urgent citrus blackfly problem in 1953. Late in 1952 and early in

1953 a general infestation was eradicated from 56 city blocks in Matamoros, or at least reduced to such a low level that danger of an invasion of the Rio Grande Valley of Texas has been minimized. Four applications of spray were made cooperatively by the Mexican National Blackfly Committee and Bureau workers. Spray machines, drivers, and most of the insecticides needed for this work were provided by the national committee. One small additional infestation was later found, but is believed to have been eradicated.

In January 1953, 17 properties were found infested with the citrus blackfly in Hermosillo, Sonora, Mexico. These infestations are from 1 to 5 blocks distant from the zones sprayed in 1951 and 1952. None of the infestations appeared to have been established more than 8 months, nor was infestation found in the areas previously infested in this town. Bureau personnel met with Mexican officials and citrus growers of the area to plan a citrus blackfly eradication program. Spraying of infested properties and security zones around them was completed on May 30. The coverage of the 17 known infested properties and security zones required a total of 23,300 gallons of a cube-oil formula applied to 2,648 citrus trees and other host plants on 267 properties. A quarantine station was set up on the highway south of Hermosillo to protect the area against reinfestation. This station was manned by three inspectors, one each being furnished by the Bureau, the State, and the Citrus Growers' Committee.

Cooperative quarantine program in northwestern Mexico

The Bureau furnishes technical assistance to the Mexican Department of Agriculture in a cooperative quarantine program in the northwestern area of Mexico to prevent the establishment of the citrus blackfly and other injurious insects close to the International Border, thus protecting agricultural areas of the western United States from infestations of important pests that do not exist there. During the year inspections were made of 75 coastwise vessels at Ensenada, Baja California; 5,009 passenger and cargo planes at Mexican airports along the California border; 3,535 freight and passenger railway cars in Sonora; and more than 370,000 pieces of baggage belonging to more than 229,000 rail, airline, and highway passengers. Inspections resulted in the interception of more than 4,500 lots of prohibited plant material, including plants and plant parts infested with the citrus blackfly and the Mexican fruit fly. These interceptions included host material of the pink bollworm and the boll weevil.

Introduced parasites greatly reduce citrus blackflies throughout Mexico

In general, citrus blackfly infestation in practically all regions of Mexico, except the northwest, was greatly reduced by parasites during the year. In June 1952 all chemical control was discontinued in the areas south of Victoria and Guaymas.

The four citrus blackfly parasites introduced from India are now well established in Mexico. *Prospaltella smithi*, which started out so auspiciously 2 years ago, is now relegated to a minor position, except in a few regions where the climate appears suitable.

Amitus hesperidum continued its role as the most important all-round blackfly parasite in Mexico. This parasite is now established

in all climatic regions in the country. In many of these regions it has shown a rapid buildup and good control in from 8 to 12 months. In the States of Morelos, Veracruz, Puebla, and San Luis Potosi (Valles) many groves and even entire localities are now commercially clear of blackflies because of *A. hesperidum*. Eighty-five million adults of this species were collected and released in infested groves all over Mexico during 1952.

Prospaltella clypealis appears unable to reduce a heavy blackfly infestation. Once the infestation is diminished to a low degree this species performs well and gives efficient control. It has been released in most regions. In some groves in regions such as Colima, Morelos, and Valles it has so completely controlled the pest that the latter is difficult to find.

Prospaltella opulenta is established in Valles, Morelos, and Veracruz. It shows little evidence of being effective in controlling the blackfly.

Fruit Fly Investigations in Hawaii

Scores of insecticides evaluated for fruit fly control

Nearly 100 coded materials supplied by Bureau chemists and many other compounds furnished by insecticide companies were screened in the laboratory in the 1952 program to find promising new fruit fly insecticides. Among the coded compounds there were six that warranted further tests.

In field tests, methoxychlor wettable powder, applied at the rate of 20 pounds of toxicant per acre, was as effective on guava foliage for 19 days after application as 10 pounds of DDT per acre. Each gave from 75- to 80-percent kill within 24 hours. The performance of parathion was not improved by the addition of a sticker. Twelve days after an application of parathion at the rate of 5 pounds per acre, the residues were still 86 percent effective. Isodrin was equal to dieldrin in residual effectiveness but neither was as effective as parathion until after 12 days of weathering. Malathion and Systox were very promising fruit fly insecticides but neither of them had any substantial residual action against adult flies after 4 days. Fungicides such as wettable sulfur, ferbam, and tribasic copper sulfate did not adversely affect the residual toxicity of DDT or parathion deposits.

In mist blower applications to 6-acre guava plots, parathion was three times as effective as lindane when each was used in a bait spray at the rate of one pound of 25-percent wettable powder per acre. This bait spray also contained 0.5 pound of protein hydrolysate and 2.5 pounds of raw sugar per acre as the attractant ingredients. Subsequent experiments have indicated that sugar may not be necessary in the foregoing bait spray for control of the oriental fruit fly; with the sugar omitted the bait spray is highly effective against the melon fly. Other recent tests have shown that dieldrin and malathion are effective substitutes for parathion in the bait spray but that DDT and CS–708 are less effective.

Bait sprays protect mangoes from fruit flies

A bait spray treatment costing $30 an acre was used to protect a mango crop that sold for $750 an acre at the orchard, in tests conducted in 75 acres of mango orchard on Maui and Molokai, T. H.

There have been few experiments in commercial mango orchards because of the scarcity of suitable large plantings in the Hawaiian Islands. In the Maui tests, application of a bait spray containing 1 pound protein hydrolysate, 5 pounds raw sugar, and 4 pounds parathion 25-percent wettable powder per acre resulted in a 97-percent reduction in fruit fly infestations during the 2 weeks' period after each of three sprayings. The prespray infestation level was 4.4 larvae per pound in fruit picked at the color-break stage of ripeness. Parathion 25-percent wettable powder alone at the rate of 10 pounds per acre gave 95-percent control. CS–708 plus malathion, 5 and 0.75 pounds, respectively, of the toxicant per acre gave 93-percent control, and 6 pounds of DDT 50-percent wettable powder plus 1.5 pounds of EPN–30 gave 92-percent control. Fly populations in adjacent untreated 3-acre plots were greatly depressed by the spray applications, rendering them worthless as bases of comparison. Generally, parathion residues from the bait sprays were less than 0.5 p. p. m. one day after spraying. The other treatments applied were more expensive and the danger of excessive residues from them was far greater. On Molokai, similar results were obtained with bait sprays containing parathion.

DDT residual spray developed for fruit packinghouse interiors

DDT proved to be the most effective of six insecticides used in tests to find the best material to apply to interior surfaces of packinghouses to destroy oriental fruitflies that might infest fruits during post-fumigation packing operations. Where these insecticides were applied to nine different types of surfaces, 10 ounces of DDT 75-percent wettable powder in 1 gallon of water gave the best results. Residues from this spray gave 99.9-percent control of flies exposed to the residues on each of the surfaces for 24 hours at intervals during a 150-day period.

Male oriental fruitfly annihilation effective in control

A promising new method of oriental fruitfly control has been found as a result of further experiments with methyl eugenol. This chemical is a powerful attractant for the male of this species. By attracting the males to poisoned methyl eugenol feeding stations, huge numbers are killed before they are able to fertilize newly emerged females.

As now developed, this method is the first known successful attempt to control an insect by annihilation of the male population with a poison bait. The method may have even greater value than presently indicated in situations where the entire infested area can be treated and the influence of migrating fertile females is removed.

The first large-scale test of this method conducted in Opaeula Gulch on Oahu was concluded in 1952 after 28 months of operation. Guavas within this ¼- to ½-mile-wide gulch were protected by 55 poisoned feeding stations distributed for 1½ miles along its rim. Infestations in the fruit averaged 76 percent less than the average infestation in surrounding, unprotected gulches.

Additional information on this method of control was obtained in tests initiated on Hawaii in January 1952. One of the test areas was a 6-square mile area on the wet Hamakua Coast, extending from sea level up the slopes of Mauna Kea for 2½ miles to the forest line at an elevation of 2,100 feet. The other was a small area of isolated

guava in a comparatively dry environment on the south slope of Kilauea at an elevation of about 2,500 feet.

The reductions in the substantial infestations at median elevations were comparable to those obtained in the Opaeula Gulch experiment. The cost of the Hamakua operation, exclusive of strictly research items, averaged about 25 cents an acre per year.

The much smaller Kilauea experiment failed to produce any consistent reductions in infestations because of frequent and unanticipated migrations of flies into the small test area. More than 100,000 flies were caught in a trap located at an elevation of 3,600 feet and ½ mile from the nearest fruits.

Smooth Cayenne pineapples not a sastisfactory oriental fruit fly host

An extensive study in Honolulu showed that the smooth Cayenne variety of pineapple, the principal commercial variety in Hawaii, cannot be considered a satisfactory oriental fruit fly host even though this fly deposits a few eggs in it under field conditions. However, normal flies do develop in certain experimental pineapple varieties and hybrids. No adult oriental fruit flies were reared from more than 10 tons of Cayenne pineapples collected in fields throughout the Hawaiian Islands. Only rarely was a fruit fly able to complete development in several hundred whole pineapples in each of which thousands of eggs were laid under forced conditions. These results have led to release of the smooth Cayenne variety from treatment requirements.

Mainland climates in which fruit flies might survive studied

A second series of simulation-of-climate studies was initiated in 1952 in cooperation with the University of California Agricultural Experiment Station to study fruit fly development in climates typical of El Centro, Auburn, and San Jose, Calif., Houma, La., and Orlando, Fla. The Mediterranean fruit fly, oriental fruit fly, and melon fly, the three fruit fly species in Hawaii that are of potential importance to mainland agriculture, were included in the new studies.

Uninterrupted development of all three fruit flies throughout the simulated winters was possible only in the Houma and Orlando cabinets. The Mediterranean fruit fly developed at a faster rate, but was not able to attain as high population levels as the other two flies. The melon fly and Mediterranean fruit fly proved to be somewhat more tolerant of low temperatures than the oriental fruit fly. This agrees with previous field observations.

Bioclimatic studies now completed indicate that all three fruit flies could survive very well in some parts of Florida and in the Gulf Coast area of Louisiana. Their capacity to maintain themselves in California would probably depend upon the extent to which they could bridge over periods of unfavorable winter weather as adults, or as pupae in the soil. Establishment, reproduction, and development of all three flies undoubtedly could occur in any mainland area during the most favorable seasons of the year if suitable host material were available.

Cooperative biological-control program continued

The Territorial Board of Agriculture and Forestry continued to propagate and distribute several of the introduced parasites and carry on recovery studies. The University of Hawaii continued its parasite

establishment, spread, and evaluation studies. The Bureau's contribution consisted of a few observations on the habits of established parasites and numerous records of parasitization of fruit flies infesting various hosts.

Parasites recovered for the first time in 1952 included Opius No. 2 (New Caledonia), Opius No. 3 (Siam), *Syntomosphyrum indicum*, and *Tetrastichus dacicida*, the latter an African importation.

Studies by University of Hawaii entomologists and incidental records obtained by Bureau workers showed that the egg-larval parasite *Opius oophilus* continued to be by far the most effective of the introduced species. The proportion of larvae parasitized by this and other parasites was somewhat less during most of 1952 than 1951. It is becoming increasingly apparent that a definite fruit fly problem will remain despite the work of natural control agents unless there are unexpected major changes in factors affecting fly abundance.

University of Hawaii studies showed that a fungus (*Mucor* sp.) is an important factor in the mortality of oriental fruit fly eggs.

Treatments permit movement of fruit from Hawaii

As a result of the development of ethylene dibromide treatment for fruit fly-infested fruits and vegetables, exports from Hawaii to the mainland have increased from a few thousand pounds of fresh pineapple in 1948 to more than 2½ million pounds in 1952. The volume of shipments increased each month during the year. Exports of fresh papaya, which may be made following fumigation with ethylene dibromide or treatment with vapor heat, increased to 283,000 pounds during the first 10 months of 1952 despite a strike which stopped shipments during June and July.

Although 124 additional materials were screened as fumigants to be used against the different fruit flies in products to be moved from infested localities none of them proved as effective as ethylene dibromide. Most effective of the screened materials were hexyl, heptyl and octyl iodides, epibromohydrin, methyl chloroacetate, and methyl and ethyl bromoacetates.

Fruit fly investigations in Hawaii were in cooperation with the University of California, University of Hawaii, Agricultural Experiment Stations, the Territorial Board of Agriculture and Forestry, the Pineapple Research Institute, and the Hawaiian Sugar Planters' Association Experiment Station.

Mexican Fruit Fly Control

Most of the citrus fruit in the Lower Rio Grande Valley was harvested and shipped before heavy migration of Mexican fruit flies from northeastern Mexico occurred in 1952. As a result, no sterilization of fruit was required. The normal citrus-harvesting season in Texas extends from October through May, and larval infestations are most frequently found from January until the close of the harvesting season. The year 1952–53, however, was an unusual season in Texas. The fruit crop was extremely short on account of a previous heavy frost. This resulted in an early harvest. Due to this early harvesting of the commercial crop, larval infestations were discovered in Texas only in fruit retained for local consumption. Operation of several thousand fly traps in the groves, however, indicated the usual migration of flies from Mexico. The production of a normal crop would have meant

widespread larval infestations, with sterilizing required for fruit shipped from the area late in the season.

Codling Moth Resumes Important Role

Despite the fact that most commercial fruit growers obtained good control of the codling moth, this pest was generally more abundant and caused more injury in 1952 than in any year since 1946, when DDT came into general use for its control. Growers are concerned, but thus far weather conditions particularly favorable for the development and activity of this insect appear to have been an important, if not the most important, contributing factor. Some field experiences during 1952 pointed to possible differences in DDT formulations as another contributing factor. Thus far, the development of resistance of the codling moth to DDT appears to be a threat rather than a proved reality.

In the meantime research continues in an effort to develop supplements or substitutes for DDT to control this pest. Several promising materials are available.

Two New Mite Species Spread to Midwest Apple Orchards

A survey of 20 representative apple orchards in the Midwest during August and September 1952 disclosed two species of mites present that had heretofore been unreported on apples from that area. The two species were *Tetranychus canadensis* (McGregor) and *schoenei* McGregor. Orchards in which these mites were found extend from Goshen, Ind., near the Michigan State line, southward through Indiana, southern Illinois, and western Kentucky to central Tennessee at Jackson; and from Louisiana, Mo., eastward through Illinois to Yorktown in eastern Indiana.

Introduced Oriental Fruit Moth Parasites Become Established

Two recently introduced Chinese parasites of the oriental fruit moth, *Agathis festiva* and *Phanerotoma grapholithae*, first released for colonization in New Jersey and North Carolina in 1951, were recovered from colony sites in New Jersey in 1952. The original stocks were furnished by the California Agricultural Experiment Station. Colonization was continued in 1952, attention being given to releases in south central Pennsylvania and in Connecticut. Thirty-seven separate releases of *Agathis* and 23 of *Phanerotoma* were made in the two States. Colonies of *Phanerotoma* were also furnished to the Citrus Experiment Station, Riverside, Calif., for colonizing against the oriental fruit moth in Orange County, Calif.

Two Leafhoppers Dominant in Western X Virus Disease Transmission

Two of the four leafhoppers that are demonstrated vectors of western X disease and little cherry, *Colladonus geminatus* and *Scaphytopius acutus*, are dominant in Washington and northern California and appear to be the important economic carriers of these diseases. These observations were made in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Agricultural

Experiment Stations of California, Oregon, Washington, and Utah.

In Washington it was conclusively proved that three leafhoppers, *Scaphytopius acutus*, *Fieberiella florii*, and *Keonolla confluens*, are vectors of the western X disease and little cherry disease. These three are in addition to the previously confirmed vector, the geminate leafhopper, *Colladonus geminatus*. The causal viruses have been transmitted from peach to peach, from cherry to peach, from chokecherry to peach, and from cherry to cherry. A tentative lead was obtained also in Washington that *Gyponana hasta* might be a fifth leafhopper vector of western X-disease virus. This latter species is considered to be of sparse distribution in areas thus far invaded by these diseases.

More Effective Controls Developed for Pecan Pests

Hickory shuckworm infestation in pecan shucks at harvest may be markedly reduced by means of late August and early September applications of EPN and a few other insecticides, according to field experiments in both Florida and Georgia. Under Florida conditions, in which 92 percent of the shucks on untreated trees were infested at harvest, the most effective control included three early- and two late-season applications of EPN. This treatment reduced infestation by 45 percent. EPN was somewhat more effective than DDT and parathion and much more so than Metacide. Under Georgia conditions, in which 73 percent of the shucks on untreated trees were infested at harvest, three late-season applications of EPN reduced infestation to 8 percent. These late-season applications were as effective as six applications, three early and three late, or nine applications made throughout the season.

Dusts containing 1 percent parathion and 40 percent sulfur gave good control of the mite *Tetranychus hicoriae* on pecan when applied either with ground machinery or by airplane. It appeared more difficult to obtain thorough coverage on large pecan trees with airplane applications of dusts than with either sprays applied by airplane or dusts applied with ground machinery. Dusts containing enough BHC to give 3 percent of the gamma isomer and 12 percent of other isomers plus 40 percent of sulfur gave good results against *hicoriae*. This treatment appeared to act more slowly against mature stages of the mite than concentrated parathion sprays and parathion-sulfur dusts.

Dusting with 1 percent parathion was effective against the black pecan aphid over a period of several years in northwest Louisiana. Results obtained with parathion-sulfur dusts against *hicoriae* indicate that it will be possible to effect control of both of these pests through the use of this dust mixture.

Vectors of Quick Decline Disease of Citrus Sought

Following the finding of "quick decline" or tristeza on Florida citrus, studies of possible insect vectors of the disease were started at Orlando, Fla., in cooperation with plant pathologists of the Bureau of Plant Industry, Soils, and Agricultural Engineering. One natural grove transmission has been demonstrated from a mature diseased tree to a young lime seedling nearby. The vector responsible for this transmission could not be determined. Surveys of groves, both in central Florida and on the east coast, have disclosed three species of

aphids and one planthopper that may be possible vectors. Two hundred and fifty transmission experiments with the three aphids *Aphis gossypii*, *Toxoptera aurantiae*, and *Aphis spiraecola* have been set up. Some of the test plants already show symptoms similar to tristeza but such transmission has not yet been confirmed by bottle-graft transfers. Vector surveys showed that *spiraecola* is more abundant in central Florida than the other two species. On the east coast *aurantiae* and *gossypii* are more plentiful than *spiraecola*. All species of aphids were scarce during the first half of 1953.

The planthopper under suspicion as a vector is *Cyarda melichari*. This is the first time this species has been reported on citrus. The specimens collected during the surveys will be used in further laboratory transmission tests.

First-Instar European Chafer Larvae Most Susceptible to DDT

Complete mortality of first-instar larvae of the European chafer was obtained within 1 week when 10 pounds of DDT per acre was applied to Dunkirk sandy loam. Two weeks were required in Ontario gravelly loam. Second-instar larvae were killed within 6 weeks with 15 pounds of DDT per acre. Third-instar larvae survived for more than 8 weeks in 21 pounds of DDT per acre. It is apparent that, if these grubs are to be eradicated in nursery soils, the DDT should be applied before the eggs hatch. Tests on which these findings were made were performed at Newark, N. Y., in cooperation with the New York Agricultural Experiment Station at Geneva.

Hall Scale Eradication

Surveys of almond and peach acreages in the vicinity of Chico, Calif., where Hall scale has persisted since 1934, disclosed infestations of this minute scale insect on three additional properties in the Chico area. Additional infestations were found on six properties in three city blocks in Oroville, Calif. These properties represent an extension of known infested localities. A total of nearly 82,000 host plants beyond the limits of known infestation were inspected during the fiscal year.

An inspection of more than 6,250 deciduous fruit trees on 159 properties that had previously received a final hydrocyanic gas fumigation failed to reveal any living Hall scale. The control work was in cooperation with the California Department of Agriculture.

At the Bidwell Park infestation in Chico, host trees on properties within a 2,500-foot radius of the infestation were treated. Because of the lightness of the Davis, Calif., infestation, treatment there was limited to an area within a 1000-foot radius.

The control program consists of either the removal and destruction of infested trees or the application of oil sprays to host plants on infested properties coupled with three consecutive annual hydrocyanic acid fumigations during the period of host dormancy.

During the 1952–53 fumigation program, 3,716 trees were treated. These included all known infested plantings which had not previously been fumigated, as well as nearby plantings in the new treatment areas in Chico and Davis.

There was increased acceptance of the voluntary host-removal program in the treated areas. More than 4,300 hosts were voluntarily removed and destroyed during the year, 2,254 of which were in the Oroville area. This represents removal of approximately 71 percent of the hosts there. In addition, more than 5,100 volunteer seedlings were removed from the vicinity of infested plantings.

Sprays Nonpoisonous to Natural Enemies of Apple Pests Investigated

Investigations were expanded on the effects of insecticides on the natural enemies of apple pests in Eastern States orchards, in order more effectively to coordinate biological with chemical control.

Other orchard tests in the State of Washington showed that a new spray, Q–137, has more harmful effects on the coccinellid beetle *Stethorus picipes*, a predator on phytophagous mites than does DDT. Among various insecticides tested for control of the codling moth CS–708 was found to have the most harmful residual effect on *Stethorus*. Studies at another orchard showed that *Stethorus* utilizes mites on various legumes to build up high populations and then becomes active on apple trees in numbers exceeding anything expected on the basis of mite populations on the trees. It was also observed that *Stethorus* beetles become fairly abundant on unsprayed legumes infested with mites outside the orchard. When the mite population there becomes low, the beetles move to the cover crop legumes in the sprayed orchard and rapidly reduce the mite population on these legumes.

HONEY BEES AND OTHER POLLINATING INSECTS

Antibiotics Effective Against Destructive Honey Bee Diseases

Fumagillin, an antibiotic, may be effective against Nosema disease in honey bees, according to experiments conducted in 1952. Bees inoculated with the disease and fed with this substance at concentrations of 16.7 mg. per liter of sugar sirup remained essentially free of infection. Bees heavily infected for 7 to 9 days showed a more or less constant decrease in the level of infection following continuous feeding of fumagillin. This antibiotic appeared ineffective, however, when given in water. Tests are continuing to determine the optimum effective concentration of fumagillin, its effect on longevity, and stability in various solvents and food substances.

Streptomycin at 0.6 gram per gallon of sugar sirup, gave promising results against European foulbrood when fed to infected colonies at Madison, Wis.

Steam Sterilization Rids Pollen of Foulbrood Contamination

A method for sterilizing pollen that may be contaminated with European foulbrood organisms was developed at the Bureau's laboratory at Madison, Wis. Steam autoclaving for 20 minutes at a pressure of 14 pounds produced the temperature necessary to sterilize the pollen if it is spread sufficiently to allow penetration of the steam. Pollen treated in this way seemed to be as palatable as untreated pollen

to the bees, but pollen supplement "cakes" made from it tended to harden sooner. Such sterilization is especially desirable when trapped pollen is used in feeding pollen supplement.

Honey Bee Sex Now Determinable in Early Larval Stage

A technique developed during the past season for distinguishing male and female honey bee larvae no more than 12 hours old will be utilized in a continued search for adult biparental male honey bees. Such males have never been discovered although theoretically possible. By means of this technique the search will be extended to include early larval stages. A "biparental" male would be a drone that developed from an egg and sperm, both of which contain the same sex allele. The indications are that such a union of like sex alleles results in failure of the egg to develop into an adult bee. Normally the drone develops from an unfertilized egg.

Hairless Honey Bee Mutation Found

A new honey bee mutation, apparently previously undescribed, has been found. It has been named "hairless" because of the almost complete absence of hairs on the bee's body. Preliminary tests indicate that this characteristic is linked with an eye color. A stock of the new mutation has been established and its linkage with other mutations and sex is being studied. This increases to six the number of mutant stocks on hand.

Two-Queen Colonies Outproduce Those With Single Queen

Proper methods of profitably managing two-queen colonies were studied in cooperation with the Wisconsin Agricultural Experiment Station. Although the difference in yield between single- and two-queen colonies was not as great in 1952 as in some previous years, 18 two-queen colonies produced an average of 216 pounds of honey each as compared with an average of 143 pounds for 20 single-queen colonies.

Bees Prefer Cane Sugar Sirup to Any Other

Tests with caged worker bees showed that the bees prefer cane sugar sirups to sirups made of dextrose, dextrose and saccharin, levulose, levulose and saccharin, maltose and saccharin, or sirups made of equal quantities of levulose, lactose and sucrose, of dextrose, lactose, and sucrose, or of levulose and sucrose. This indicates that the bees preferred cane sugar sirup to sirup from simple sugars or various combinations of sugars. Saccharin appeared to make dextrose more desirable and levulose less desirable. The addition of saccharin to maltose sirup did not increase the desirability of the latter. Addition of powdered propolis appeared to make cane sirup more desirable than cane sirup alone, whereas the addition of saccharin had practically no effect.

Unheated Hives Equal to Those Electrically Heated

Package bees installed April 14, 1952, in electrically heated hives, in which a temperature of 85° F. was maintained, appeared to hold up

longer than those in unheated check hives, and they also had approximately 20 percent more sealed brood 21 days after installation. Brood counts during the fifth and seventh weeks after installation, however, showed no significant differences between the two groups. This work was done in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Wisconsin Agricultural Experiment Station.

Direct-Drive Increases Honey Extractor Capacity

Substitution on a honey extractor of a direct-drive for the conventional friction-drive power has been found to be a major improvement since it permits automatic speed control. A 50-frame radial extractor, equipped with such an automatic speed control and with metal baskets accommodating 80 standard or 90 shallow frames, appears capable of extracting 1,500 to 2,000 pounds of honey per hour, as compared with 3,000 to 5,000 pounds per day by usual commercial methods of extraction. This work was done in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Wisconsin Agricultural Experiment Station.

Bees May Reverse Preferences for Alfalfa and Red Clover

Previous years' observations have disclosed that alfalfa nectar, because of its higher sugar content, is more attractive to bees than is red clover nectar. During the summer of 1952 it was found that this is not always the case. In one locality red clover at certain times was more attractive to honey bees than was alfalfa, despite the fact that the alfalfa nectar had a higher sugar concentration. The presence of an adequate concentration of bees did not seem to explain why this occurred.

The same kind of competition for bee visits that exists between different species of plants also exists between fields of the same species, according to work done in 1952. Thirty-eight colonies of bees were moved into a red clover field of about 17 acres. Because of drought, this field had made a poor recovery after removal of the hay crop. In only a small part of the field was the bloom heavy enough to justify harvesting the seed. The average yield was about 72 pounds of seed per acre. Since the clover in this field was not attractive to bees in the early part of the blooming period, most of them neglected it in favor of alfalfa in nearby fields. Of greater interest was the fact that they also flew to a red clover field about ¾ mile to the west where they worked heavily. The resulting seed crop in the latter field was 192 pounds per acre, a good yield for the amount of bloom.

Observations covering the entire 6-week 1952 blossoming period of red clover showed that 91.7 percent of the flowers appeared within a 3-week period. Apparently none remained fresh for more than a week. This shows the importance of having on hand, especially during bad weather, a supply of bees that will be adequate to insure pollination in the relatively short period during which the blossoms remain open.

Bees From a Different Environment Prove Best Alfalfa Pollinators

Bees from a locality having a flora different from that in the locality to which they are moved may collect more alfalfa pollen than bees

moved into the locality from another alfalfa field. For example, a group of colonies moved to an alfalfa field from a mountain location devoid of alfalfa collected an average daily weight of alfalfa pollen almost twice as large as the group moved from another alfalfa field.

These observations were made from weight data and from determinations of the floral sources of more than 1,200 samples of pollen pellets collected in 1951 in pollen traps placed at the entrances of hives located in an alfalfa field.

Bee-Trapped Pollen Withstands Subzero Temperatures

Bee-trapped almond pollen was found viable after being stored for a year in a deep-freeze at −13° F. This was disclosed during experiments at Davis, Calif., in cooperation with the Pomology Division of the California State College of Agriculture, to compare the value for artificial pollination of fruit tree blossoms of fruit pollen trapped from bees and hand-collected pollen, each of which had been stored over winter.

Insecticides on Cotton and Alfalfa Cause Heavy Bee Mortality

Bee mortality from insecticides applied to cotton in Arizona was the greatest since the years of widespread use of arsenicals. Parathion and BHC were the insecticides that were particularly lethal to bees. The highest mortality resulted from direct applications and drifting of these materials to apiaries. Honey yields were low in many apiaries because of the repeated destruction of field bees.

Observations were made of the behavior of a bee colony suffering from the effects of BHC. Within an hour after exposure to this chemical bees began hastily leaving the hive, tumbling, somersaulting in headlong flight, often tumbling along the ground 2 or 3 feet before taking wing, after which their further flight away from the hive became stable. Others unable to fly, tumbled and gyrated over the ground near the hive entrance and eventually died.

When the hive cover was removed the bees were found to be much more agitated than usual. They reacted in a very agitated manner to the first puff of smoke and became mean. As more and more of the affected bees poured out of the hive entrance, bees remaining within became less organized and gathered in small clusters, each cluster appearing like that formed when a queen is being "balled." All or most of the bees vacated the hive to cluster near the entrance or in nearby treetops. The queen accompanied the bees, although this does not always occur. With all adult bees gone, the sealed brood died in the deserted combs. The larger larvae crawled from their cells to succumb on the bottomboard, while younger larvae died in their cells, probably from starvation rather than poisoning. Adult bees that recovered from the poisoning returned to the hive within a day or two. From other observations, it has been found that if the queen and enough of the adult bees survive, the colony begins to recuperate.

In Utah an evening application of 6 ounces of TEPP per acre of alfalfa killed 4 percent of the average daily population of honey bees visiting the field. Early morning applications of 2 ounces of aldrin, 6 ounces of TEPP, 10 ounces of malathion, or 4 ounces of heptachlor per acre resulted in respective mortalities of 7, 21, 30, and 35 percent. Insecticides that cause more than 10 percent mortality under the condi-

tions of these tests are considered too toxic to honey bees to be used on fields of blooming alfalfa.

Melissodes Is Valuable Cotton Flower Pollinator

Melissodes sp., one of the solitary flower-visiting bees, was found to be the most abundant insect visitor on cotton flowers, in work done in Arizona in cooperation with that State's Agricultural Experiment Station. This bee is highly valuable as a pollinator of this plant and should be given as much protection as possible. It was found nesting in the cotton fields. Tunnels to its nest were usually of dried leaves located on the ridges in the irrigated fields above the high-water mark.

FOREIGN PARASITE INTRODUCTIONS

In Europe, the Mediterranean region, and India Bureau personnel continued to collect, rear, and ship to the United States the natural enemies of insects and weeds that are destructive agricultural pests here. Headquarters for the work in Europe and the Mediterranean region are in France, with temporary subheadquarters in Spain. Temporary headquarters in India are near New Delhi. Investigations during the year included, among others, the following activities:

Sweetclover weevil.—A total of 3,394 cocoons and 927 adults of three species of parasites were collected and reared in France. These were shipped to North Dakota and to Belleville, Canada, for liberation in fields infested with sweetclover weevil.

European corn borer.—Work on a limited scale with this pest was continued in France and Italy. Some 6,500 cocoons of two species of parasites and 46,000 corn borer larvae containing parasites of another species were collected, reared, and shipped to the parasite-receiving station at Moorestown, N. J., for dispatching to corn borer-infested areas.

European chafer.—From May to August 1952, a total of 8,301 reared puparia and 490 gravid females of two species of parasites of this beetle were shipped from France to Moorestown for rearing and colonization in areas of New York infested with the European chafer.

Omnivorous leaf tier.—Further investigations on the parasites of this pest were carried on. During the 1952 season 1,517 cocoons and adults representing six species of parasites were collected and reared in France. These were shipped to the parasite-rearing station at Albany, Calif., for forwarding to Oregon and colonization in infested areas there.

Gorse weevils.—A large number of adult gorse weevils were collected in France and sent to Albany, Calif., for observation and rearing under quarantine conditions. It is planned to liberate progeny of these weevils in fields infested with weed gorse in California.

Beet leafhopper.—Investigations of the natural enemies of leafhoppers of the genus *Circulifer* in Spain were started in April 1952. A survey was made in 16 provinces in central and southern Spain to determine leafhopper presence and abundance. From about the middle of July to early in November, 14 shipments of leafhopper material were sent to Albany for rearing egg parasites for colonization against the beet leafhopper.

Pink bollworm.—Investigations of the natural enemies of this insect pest were started in India the latter part of June 1952. The first

few weeks were spent in making a general survey of the various cotton-growing areas in India. From this survey it was decided to concentrate the work in northern India until the end of 1952. Temporary headquarters were set up at the Indian Agricultural Research Institute about six miles from New Delhi. Although several species of parasites emerged from pink bollworms collected in the fall from various localities in northern India, only two species appeared to be of any importance. These are *Bracon brevicornis* and a species of *Apanteles*. Laboratory breeding work was carried on with the former species, and 4,000 parasite cocoons were reared and shipped to Moorestown for rearing and forwarding to Brownsville, Tex., for colonization in pink bollworm-infested areas. Thus far, laboratory breeding of the species of *Apanteles* has not been successful.

Wheat stem sawfly.—Two species of wheat-stem sawfly parasites from Europe were sent to North Dakota and Montana for liberation.

CONTINUED PROGRESS IN KLAMATH WEED CONTROL

Chrysolina gemellata, a beetle originally introduced into California from Australia, is continuing to give very good control of the noxious Klamath weed. Effective control has been demonstrated at one or more release sites in practically all the major infested counties in California and at many of the sites in Northwestern States where this insect predator has been liberated. In several counties the beetles are at the "snowballing" stage. Huge increases in acreage brought under control can be expected next year. Observations have disclosed that shade may be a definite deterrent in control of the weed by this insect, since egg-laying adults apparently move out of heavy shade into warmer, sunnier locations. In general, this may be advantageous in getting a widespread distribution of the beetle.

FOREIGN PLANT QUARANTINE ACTIVITIES

Plant quarantine inspectors examined during 1952 more than 78,000 airplanes carrying more than 1½ million passengers. More than sixty thousand lots of contraband plants or plant products were intercepted during these inspections. Much of this material contained insect pests and plant diseases. Interceptions included such notoriously destructive forms as the citrus blackfly; oriental, Mexican, West Indian, and Mediterranean fruit flies; the olive fly; and a bean pod borer.

During the year, 195,000 lots of restricted or prohibited material were intercepted during the inspection of ships, trains, motor trucks, and nearly 4½ million foreign parcel post packages. Interceptions from these sources included the golden nematode, giant African snails, citrus canker, and black spot of citrus.

Inbound vehicular traffic over the Mexican border has nearly doubled in the past 4 years. The 12,800,000 vehicles entering during 1952 were nearly 1½ million more than those entering in 1951. Baggage inspection at the Mexican border increased 56 percent over the previous year.

At the Bureau's inspection house at Hoboken, N. J., 1,673 commercial importations were entered. Interceptions there of injurious insects, plant diseases, or nematodes numbered 495 lots.

During the year 9,500 import permits were issued, amended, or cancelled. At the end of the year there were in effect 4,830 continuing permits for the entry of plant propagating material and 5,400 for entry of other kinds of plant products. There were 5,800 permits issued during the year for entry of individual shipments of plant propagating material and 840 for other types of plant products.

Careful inspection of plants imported by the Department of Agriculture for scientific purposes disclosed large numbers of bruchids from 11 different countries, scale insects, thrips, whiteflies, wood borers, leaf chafers, pink bollworms, and two species of cotton borers. These importations were fumigated or otherwise treated.

Rusts and smuts particularly destructive to cereal crops were also frequently encountered. From numerous importations of foreign grass seed to be used in improving our grazing lands, numerous rusts, smuts, and other diseases were found and appropriate safeguarding measures applied.

Treatment or regrinding was required of large quantities of cottonseed meal, hulls, and cake imported for use during a cattle-feed shortage in the Western States. Such treatment was required to destroy any pink bollworms that might be present in uncrushed cottonseed.

Point-of-origin inspection of bulbs in The Netherlands and Belgium, started during 1951, was continued with very satisfactory results. From July 1952 through January 1953, 473 million bulbs and bulblets were inspected in The Netherlands and nearly 15 million in Belgium prior to shipment to the United States.

There has been a large increase during the past 4 years in the number of plants imported for growing under postentry quarantine before release. These postentry restrictions have not proved to be a deterrent to those needing plants in commercial quantities. Importations for growing under postentry restrictions increased from 494 shipments of 1,066,000 plant units in 1949 to 729 shipments of 3,033,000 units in 1952. The major part of this increase was due to a relatively few large importations of a few genera, such as *Rosa*, *Malus*, *Acer*, and *Salix*, which represented new selections or items in short supply in the United States. There was no corresponding increase in importations by amateur or noncommercial growers. Observations of one lot of plants growing under postentry quarantine showed the presence of the rust *Gymnosporangium sabinae* (Dicks.) Wint. on junipers. The infected plants were rogued and destroyed. This rust causes a leaf spot on pear, an alternate host.

Regulations governing the entry of mollusks were promulgated effective October 22, 1952, under authority of the Mollusk Act of September 22, 1951 (65 Stat. 335, 7 U. S. C. Sup. 441). These regulations require such treatments or safeguards as may be necessary to prevent entry of the giant African snail or other harmful mollusks. Returned military equipment and similar materials have been found to be the principal carriers of the giant African snail.

Thousands of lots of destructive insect pests and plant diseases were prevented from entering the country with cargoes of imported plant material. Many of the commodities involved are known to constitute a pest risk and therefore require treatment as a routine condition of entry. Many times during the year pests and prohibited plant material were found under unusual circumstances as a result of alert-

ness on the part of inspectors at ports of entry. Among products requiring fumigation or other treatment as a condition of entry were used burlap, because of the possibility of contamination with the pink bollworm, other cotton pests, or with golden nematode cysts; broomcorn, because of infestations of larvae of the European corn borer and durra stem borer; and Hawaiian fruits and vegetables because of destructive fruit flies. Cotton and cotton products were fumigated or otherwise treated on account of the pink bollworm. Lily-of-the-valley pips, nursery stock, plants, seeds, chestnuts, cipollini, and other products were fumigated or otherwise treated to prevent introduction of a wide variety of pests with which they are known to be infested in the countries of origin.

Quarantine actions affecting 5 domestic and 9 foreign quarantines were taken during the year and revisions were made of the summaries of the import requirements of 17 foreign countries and of the plant quarantine requirements of 6 States.

Plant quarantine service was inaugurated in the Virgin Islands in 1952 by assignment of two inspectors, one on St. Thomas and one on St. Croix.

A survey was completed to determine need for safeguarding vessels passing through the Panama Canal to prevent establishment of the oriental fruit fly and other destructive pests in that area and their subsequent possible spread to the continental United States.

In accordance with financial and other arrangements with the Governments of Australia and New Zealand, planes leaving Hawaii for those countries were inspected prior to departure to prevent carriage of the oriental fruit fly and other pests.

The number of export certificates issued for domestic plants and plant products to meet plant-quarantine requirements of foreign countries increased about 12 percent over the previous year—to nearly 30,000. These were issued at 53 ports to cover 115 types of plants and plant products in more than 9 million containers and consigned to 116 countries.

TRANSIT INSPECTION

Approximately 1,210,000 shipments moving in interstate commerce were examined at 15 terminal points by transit inspectors of the Bureau during 1952. Of this number, 1,154 shipments were found to be moving in violation of domestic plant quarantines, 67 of which were observed by California State inspectors. In addition 3,444 shipments were reported to States as violations of State and District of Columbia plant quarantines or nursery certification requirements.

INSECT IDENTIFICATION

One of the Bureau's Diptera specialists was assigned for the month of June 1953 to cooperate with the Bureau of Animal Industry in a survey to determine the distribution and abundance of sand flies of the genus *Culicoides*. These flies are the vectors of the blue-tongue disease of sheep which is prevalent in parts of Texas, California, and several other western States.

During the fiscal year, taxonomic specialists of the Bureau identified 89,800 samples of insects for the various research, regulatory, and control activities of the Bureau, and for other Federal agencies, State

agricultural colleges and experiment stations, industry, pest-control operators, and private individuals. This total exceeded by more than 1,200 the number of identifications made in the previous fiscal year.

A grant from the Pinellas Biological Laboratory, St. Petersburg, Fla., enabled a Bureau mite specialist to make a survey of plant-feeding mites in that State. Some 5,000 miles were covered and collections made especially from imported tropical plants and wild native species. Material thus far prepared and studied indicates that the majority of the mites appear to be undescribed forms.

Among the important works prepared in the Bureau is, An Introduction to Acarology. This is the first modern, comprehensive classification of the mites and ticks to be published. It has been enthusiastically received by mite specialists and entomologists generally both here and abroad.

At the request of the Department of Defense, special research was conducted on the disease-carrying mosquitoes of a large number of specified foreign areas to supply sanitary and medical units with guides that will enable ready recognition of the medically important species. Pictorial keys designed to assure quick and accurate identification of the mosquitoes in both larval and adult stages were developed for 12 of those areas during the fiscal year. The information for these 12 areas was included on 21 pictorial keys.

ECONOMIC INSECT DETECTION AND REPORTING SERVICE COMPLETES FULL YEAR

Fifty-two weekly issues of the Cooperative Economic Insect Report were distributed during the fiscal year. This report was inaugurated in May 1952. During the year the list of individuals requesting the report increased from 1,900 to 2,774. Total circulation jumped from 2,200 copies to nearly 3,200. Information in these issues was obtained largely from State, Federal, private, and industrial entomologists, each of whom voluntarily submitted his observations on existing and potential insect conditions through a State clearing office. Each of the 48 States and the Territories of Alaska and Hawaii and the Commonwealth of Puerto Rico has such a designated clearing office.

Special insect surveys, discussions of survey methods, and reports of insect conditions throughout the States were included in the weekly issues. Permanent record files were also maintained throughout the year. For the first time since 1942 work was undertaken to bring up to date, by review of literature and records, the notes on foreign insects.

CONTROL OF PLANT DISEASES

Improved Methods Increase Barberry Eradication Accomplishments

Work continued in 18 cooperating States to eradicate species of barberry and mahonia that are alternate hosts of the black stem rust of cereals. Losses from stem rust have ranged up to 200 million bushels in a single year.

Approximately 19 million barberry bushes were destroyed on 4,100 properties in 250 counties during the fiscal year. Field crews covered 20,300 square miles. Rust observations were made by Bureau per-

sonnel and cooperators in the important grain-growing areas. Rust losses were determined and 1,400 infected specimens of grain and barberry were collected for physiologic-race determinations. A total of 303 nurseries with an inventory of 16 million barberry and mahonia plants were inspected and certificates were issued. Permits were granted to 83 dealers to ship approved barberry stock interstate.

Changes in procedures during the year have lowered operating costs for barberry eradication and have inceased accomplishments. Final reworking of areas is now done only on evidence of need, established through reconnaissance surveys, rather than on a fixed time schedule. Old barberry sites are now worked by one or two men rather than the former crews of five to eight men. State and local agencies and farm operators are being urged to assume more responsibility for the cleanup work.

Improved methods of application and new hormone-type chemicals have materially reduced the cost of eradicating barberry bushes. For example, sprays of 2,4-D were used to kill native barberry in Colorado. A combination of 2,4-D and 2,4,5-T plus a penetrant was used for similar work in Virginia and West Virginia. Less than 0.5 percent of regrowth was apparent 2 to 3 years after treatment. Field tests have shown that 2-methyl 4-chlorophenoxyacetic acid is effective in killing *Berberis vulgaris*. This chemical is now being used on a field basis in Pennsylvania and may speed eradication in heavily infested barberry areas.

There are still 33,000 square miles requiring initial barberry eradication work. More than 50,000 square miles need reworking one or more times in the future. Areas are placed on maintenance when the necessary initial work and rework have been completed to a point where barberry has been eliminated or brought under practical control. With more than 900,000 square miles in a maintenance status, increased attention is being given by Federal and State agencies to a program designed to keep this territory free of barberries. This program involves locating bushes that were missed in previous surveys or that inadvertently have been shipped in from States outside the eradication area.

Losses from stem rust in 1952 were confined principally to parts of Minnesota, North Dakota, South Dakota, and to barberry-infested areas in New York, Pennsylvania, Virginia, and West Virginia.

Race 15B of wheat stem rust, which was found on or near barberry prior to 1950, and which became widespread in 1950, extended its range throughout most of North America in 1952. This race made up about 60 percent of all races obtained from 1952 collections of rusted grains and grasses.

It has been determined that race 15B can attack all winter and spring wheats now in commercial production as well as most of the resistant parent stock used in the small-grain-breeding program. Some varieties of wheat now being used as a source of resistance to race 15B in the breeding program are highly susceptible to some races of the stem-rust fungus that were prevalent more than a decade ago. These races have persisted on barberry from year to year since that time. Of these races, 11, 49, and 139 can attack certain varieties even more severely and under a wider range of conditions than can race 15B.

Race 7 of oat stem rust comprised more than 55 percent of all of the collections obtained from rusted oat plants. This race attacks most of the varieties of oats now being grown in the principal oat-growing regions. Race 6 of oat stem rust, which has not yet become prevalent, was found again this year near barberry bushes in the northern part of the United States. It is believed that this race will spread from these barberry areas and become established independently of the barberry throughout North America, as was the case with race 7.

Cooperating State and local agencies increased their cash and contributed services by $28,400 over the fiscal year 1952. Indiana, Montana, North Dakota, and South Dakota financed all field-control work within their borders and every other cooperating State furnished some aid.

State cooperators discussed stem rust control at 198 meetings of farm and civic groups, and appeared on 101 radio and television broadcasts. They showed a color-sound film on barberry eradication 417 times, used color slides 84 times, and released 18 stories and feature articles for publication.

Accomplishments in White Pine Blister Rust Control

Combined efforts of Federal, State, and local agencies in 1952 resulted in the destruction of more than 13,600,000 ribes, the alternate host of white pine blister rust, on about 1,306,000 acres of control area. More than 800,000 acres on which the rust was brought under control were added to the maintenance area. Cooperating agencies employed about 3,000 seasonal workers on field operations during the ribes eradication season. Accomplishments were somewhat greater than in the previous year because of better seasonal workers, favorable weather, minimum interruptions for fighting forest fires, lower labor turnover, and application of improved methods. Within the areas scheduled for protection, control of the disease has been established and is being maintained on 63 percent of the State and private white pine lands, 67 percent of the Department of the Interior lands, and 57 percent of the National Forest lands.

Contractors in western white and sugar pine forests removed more than 2,540,000 ribes from 37,770 acres in approximately 14,900 man-days of labor. Most of this work was done in sugar pine areas where more than 34,000 acres were worked at an average cost of $6.51 per acre. Accumulative totals from 1946 to 1952 show that 140,660 acres have been worked by contractors in California and Oregon at an average cost of $5.52 per acre. Where work can be done under contract, the cost is from 20 to 30 percent less than by hired labor. Each year more individuals are becoming interested in contracting. This method is particularly advantageous in small areas. Specified performance standards in contracts result in efficient work. Contract work was tried on a small scale in the Lake States for the first time in 1952 and showed a saving of about 10 percent. It will be put into practice wherever economy can be effected and contractors are available. The use of an oil-soluble red marker was adopted for basal stem sprays authorized for contract ribes-suppression work.

Over 45,000 infected white pines were pruned to remove diseased parts. This work was carried on in plantations where pruning would

save valuable crop trees that otherwise would be killed by the rust.

Fifteen forest tree nurseries and their environs were surveyed during the year. These nurseries annually produce millions of young white pine for forest planting. During the surveys 2,075 ribes were removed from 7,000 acres of land. These surveys, which are made periodically as part of a continuing check on such nurseries, assure a source of rust-free planting stock. The average of 3.5 ribes bushes per acre shows that a high degree of protection is maintained.

There are nearly 26 million acres in control areas. The disease is under control on more than 16 million acres, or 62 percent. The remaining 38 percent is in various stages of completion. Some of it needs initial work. All of it needs rework to establish control of the disease. Thereafter, control areas need some follow-up work periodically to maintain this condition.

First record blister rust infections on white pine were reported during 1952 from Monroe County, W. Va.; Smith and Washington Counties, Va.; Carbon County, Mont.; Tama and Jones Counties, Iowa; Lapeer County, Mich.; and Houston County, Minn. Rust on ribes was reported for the first time from Carbon, McCone, and Prairie Counties, Mont., and Albany County, Wyo. These ribes infections extend the rust 200 miles eastward in Montana and 225 miles southeastward in Wyoming. There was no southward extension of the rust in the Sierra Nevada Mountains.

Improved equipment is extending chemical treatment of ribes to remote areas, and the use of chemicals in areas supporting high ribes concentrations is giving more efficient ribes suppression at lower costs. Chemicals do the initial job cheaper and reduce the amount of rework. On cutover areas containing numerous ribes, chemical treatment has become standard practice in western white and sugar pine areas. In all white pine forests, chemicals are proving advantageous for treating small patches of dense ribes growth occurring within large areas having a low ribes population. Hand crews are trained to recognize, mark, and bypass such patches, leaving them for later chemical treatment.

A 60-pound portable power sprayer that utilizes an eccentric-type rubber impeller pump and a 1½ hp. air-cooled motor was assembled on a special pack frame. Accessories developed for this sprayer include a 200-gallon, self-supporting, collapsible, canvas tank, and a 5-gallon combined carrying tank and gas tank fitted for direct attachment. This unit, field tested in Idaho and California, will make possible the power spraying of troublesome ribes not accessible to truck-mounted sprayers.

During July 1952, 160 acres were sprayed with low dosages of 2,4-D and with pellets containing a volatile ester of 2,4-D. These sprays and pellets caused sufficient injury to ribes to justify further tests of these low-cost methods of applying chemicals. The 2,4-D pellets appeared to be highly selective on the sensitive *Ribes roezli* and to have little or no toxicity to valuable trees and shrubs more than 2 feet tall. Repeated pellet applications can be made without damaging any except the most sensitive plants under this height. The success of these sprays, which are intercepted to some extent by trees and shrubs taller than ribes, depends on the development of herbicides more selective and more readily translocated.

Tests completed in 1953 show that 2,4,5-T may be used effectively throughout the growing season in eradicating skunk currants. Heretofore, spraying operations have been delayed until ribes leaves reached approximately full growth. This chemical also gave excellent kills when used on cultivated flowering and wild black currants.

Improved methods for more rapid resurvey of areas on maintenance to locate changes in forest cover, recurring ribes, and extension or elimination of pine areas are being studied. As part of this study, a State-owned plane was used in New York in 1952 to locate white pine stands scattered over 225 square miles of forested area. Survey work was completed in 6 hours of flying time that would have required 6 weeks of ground activity.

Halogeton Surveys

The Secretary of Agriculture authorized the Bureau of Entomology and Plant Quarantine to make a survey to determine the distribution of halogeton and, through interviews with State officials, stockmen and others familiar with western range problems, to discover its potential as a range pest. This survey was conducted during the fall of 1952. The results indicated that, of the 1,800,000 acres known to be infested, 1,125,000 were on lands under the jurisdiction of the Federal Government. Its importance as a range pest appears to be closely associated with range and herd management practices. The survey indicated that, although halogeton can be controlled in certain local areas by reseeding or through the use of herbicides, an extensive research program is needed to determine the biological and management factors which will result in the suppression of halogeton in areas where infestation is general. It was felt that halogeton cannot be eradicated with control methods now known.

Regulatory Activities To Control Phony Peach and Peach Mosaic

Phony peach, which is considered to be one of the most serious diseases of peach in the Southeastern States, has caused the loss of 3 million trees. Peach mosaic, another very serious disease in the Southwestern States, has resulted in the destruction of nearly 400,000 trees. Direct losses attributed to these two diseases in 1952 amounted to $1,600,000.

Surveys for these diseases were made in 81 counties of 17 States. More than 354,000 trees were inspected on 8,100 properties. Phony peach was found in 547 trees on 18 properties, and mosaic infection in 6,200 trees on 114 properties.

Surveys for phony peach were also made of wild plum in 89 counties of 16 States. Since this disease is symptomless in plum, the survey was made by means of a chemical test on plum twigs. More than 7,200 twigs were tested at 300 locations. One hundred and two twigs from 35 locations were found infected. The wild plum survey demonstrated that phony peach disease occurs in this wild host in much of the area in which the disease occurs, or has occurred in peach.

Programs for the detection and removal of trees infected with either of these diseases were conducted in 111 counties of 13 States. Phony peach was found in 44 counties in 8 States, and mosaic in 13 counties of 5 States. Phony peach was found in more than 106,000 trees, or

2.5 percent of those inspected. Mosaic infection was discovered in 5,400 trees, or 0.2 percent of the inspected trees.

After 2 years of area-wide inspection and removal of infested trees in Georgia, the incidence of phony peach disease dropped from 6.05 percent in 1951 to 4.77 percent in 1952. In the Fort Valley area, the most severely infected commercial growing area, the reduction was from 8 percent in 1951 to 6.3 percent in 1952.

Within the peach mosaic control area, there was a reduction in disease prevalence in 1952 in the States of Arkansas, California, and Utah. No change was observed in Texas, and Colorado infections showed an increase from 0.22 to 0.32 percent.

The 1952 inspections showed Comanche, Henderson, Mills, Parker, and Wilbarger Counties, Tex., to be mosaic-free for the third consecutive year. They are therefore eligible for release from the State's standard peach mosaic quarantine.

Four nurseries growing 17,101 trees in the peach mosaic regulated area failed to comply with certification requirements. Two nurseries with a total of 385 trees were found to be ineligible for certification under the Standard State Phony Peach Quarantine. A total of 141 nurseries propagating 870,000 peach trees, and their environs, were inspected. These nurseries were located in 25 regulated counties of 8 States.

Precautionary inspections were made in commercial peach nursery-stock-producing areas outside those now regulated under State phony peach or peach mosaic quarantines. These inspections included 35 nurseries propagating more than 1½ million trees. Approximately 34,000 trees were inspected without finding any evidence of either disease.

Twenty-three peach budwood sources and their 1-mile environs in the peach mosaic-control area were inspected and certified. These sources, totaling 79,000 trees, are located in Arkansas, California, Colorado, Oklahoma, and Texas. Three mosaic-infected trees were found and removed on properties adjacent to these certified budwood sources. Budwood from certified sources is cut under the supervision of an inspector, who also reinspects trees in the peach mosaic-regulated area before the buds are cut. Budwood sources outside the peach mosaic-infected area were inspected with negative results in 13 counties of 5 States.

Insect Vectors Are Lifetime Carriers of Phony Peach Disease Virus

Phony peach transmission tests in 1952 indicate that insect vectors of this disease when once infected can infect new trees during the remainder of their lives. This is so even though they feed intermittently for considerable periods on plants not susceptible to the disease. The most favorable period for experimental transmission has been found to be from early April until the middle of July.

Economic Damage by Phony Peach Disease Traced to Single Vector

Although four kinds of leafhoppers have been found capable of transmitting the phony peach disease, serious economic damage does not occur except in areas where *Homalodisca triquetra*, the most important vector of the disease, occurs. This has been demonstrated in

a survey for *triquetra* and *Oncometopia undata* made in Florida, South Carolina, North Carolina, Virginia, Maryland, Pennsylvania, West Virginia, Tennessee, Kentucky, Indiana, Illinois, and Arkansas. *O. undata* was found to occur throughout and even beyond the area where phony peach disease has ever been reported. On the other hand, *triquetra* was not found north of the 35th parallel, reaching that latitude only in the coastal plain of North Carolina.

GOLDEN NEMATODE CONTROL

Surveys

Surveys on Long Island during 1952 revealed an additional 1,050 acres infested with the golden nematode, bringing the total acreage infested to 10,941. More than 4,000 of these acres have been removed from agriculture by real estate development. Most of the fields containing these infestations were intermingled with or adjacent to previously infested fields in Nassau and Suffolk Counties. Inspections of 277 nurseries and retail plant sales establishments in Manhattan, Nassau, Queens, and western Suffolk Counties resulted in the finding of 10 such establishments infested with the golden nematode. This increases to 94 the number of infested establishments.

Surveys in the tomato- and potato-producing areas in nine western and in two eastern States other than New York failed to produce evidence of outlying infestations.

A single golden nematode cyst was recovered from a soil sample taken in October 1952 from a 7½ acre farm near Matawan, N. J. This farm is remote from the tomato- and potato-growing areas of New Jersey. Soil samples were collected at this farm when it was learned that waste material from a mill at Rahway that processed used agricultural burlap of foreign origin had been obtained by the farmer and incorporated into his soil. A sample of waste material collected at the mill also contained a golden nematode cyst. The mill was operating under an agreement that provided that all waste would be burned. Waste material from this mill had been spread on only one other farm. This was the State Prison Farm at Rahway. Sampling of soil there has been with negative results. The State of New Jersey immediately established safeguards at the Matawan farm. Heavy dosages of a soil fumigant were applied in the spring of 1953 to the lands under suspicion.

Golden nematodes were recovered from soil in railway cars hauling potatoes from Leon, Trinidad, and Silao in the State of Guanajuato, Mexico, in June 1953. The infested soil was intercepted at Monterrey, Juarez, and Piedras Negras. This was the first indication that this injurious potato pest occurred in Mexico.

Isolated Infestation at Mount Sinai Treated

An isolated infestation of the golden nematode in the potato-producing area of Mount Sinai, near Port Jefferson, Suffolk County, Long Island, was treated in the fall of 1952 with D-D as a suppressive measure. It is anticipated that this treatment will render nonviable from 95 to 99 percent of the cyst population in the infested field, thereby reducing further hazard of spread to other parts of this important potato-producing area.

Regulatory Activities

New York State's golden nematode quarantined area includes the potato-growing section of Nassau County and a small segment of Suffolk County. The quarantine, cooperatively enforced, prohibits movement of seed potatoes from the regulated areas and places restrictions on the movement of culinary potatoes, topsoil, root crops, tomato seedlings, vegetable and ornamental plants, as well as used machinery, containers, and equipment. The Bureau cooperated in regulating the movement of those comodities which included 506,000 bushels of potatoes and 900,000 cubic yards of top soil. Nearly 1,500 pieces of farm and other machinery used on nematode-infested properties were steam-cleaned. In addition, 20,750 burlap bags and other containers from such properties were fumigated with methyl bromide.

Soil fumigation was continued at all infested nurseries. Treating was done at 48 nursery establishments in western Long Island. Owner-operators assisted by preparing the soil and applying a water seal after treatment.

Owner-operators of 1,124 acres of infested land were compensated at the rate of $60 an acre to retire such lands from potato production to keep populations at a minimum and thus ease the regulatory problem. Costs of this program were shared equally by the State of New York and the Federal Government.

Search for a Dip To Control Golden Nematode Intensified

A screening program has been inaugurated in an attempt to find a chemical dip that will destroy golden nematode cysts attached to imported nursery plants or bulbs without injuring the living plant material. The increasing number of importations found with attached golden nematode cysts, because the plants have been grown in soil formerly used for potato culture, has created an urgent need for such a chemical. The program is cooperative with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

TOBACCO CYST NEMATODE

A cooperative Federal-State survey for the tobacco cyst nematode, previously discovered in Connecticut, was initiated in nine Southeastern States in April 1953, and was in progress at the end of the fiscal year. Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Maryland, Virginia, and Pennsylvania will be included in the survey. None of the soil samples collected during the fiscal year showed the presence of this nematode.

JAPANESE BEETLE INVESTIGATIONS AND REGULATORY ACTIVITIES

Milky Disease of Japanese Beetle Grubs Well Distributed

To accelerate spread of the milky disease of the Japanese beetle grub, 6,555 pounds of milky disease spore dust were prepared by the Bureau for the State of Maryland. Inoculated grubs used in the preparation were furnished by the State.

Since the production of spore dust was initiated in 1939, more than 184,000 pounds of the material have been prepared at the Bureau's Moorestown, N. J., laboratory.

In cooperation with State agencies, 8,673 sites including 7,772 acres in 55 counties of 4 States and the District of Columbia were treated with milky disease spore dust in 1952. Since the colonization program started in 1939, 140,973 sites involving 109,119 acres in 220 counties of 14 States and the District of Columbia have been so treated.

Field surveys in 1952 showed that this disease is well established at many sites where it was colonized years ago in Connecticut, Delaware, Massachusetts, New York, Pennsylvania, Virginia, and West Virginia. There is a tendency for the disease to be more active in the southern than in the northern parts of the infested area. One or more types of the disease have also been determined at several sites in these States where the organism was not known to have been colonized.

This line of work was placed in an inactive status at the end of the fiscal year.

Japanese Beetle Parasites Survive Two Decades

Tiphia popilliavora, an imported parasite of the Japanese beetle grub, has persisted for 20 years in the older infested areas in New Jersey and Pennsylvania, where the beetle population is now at a low level. Field surveys of 106 sites colonized two decades ago showed that this parasite is present at about one-third of these sites. Although this parasite has persisted, its effectiveness is rather low.

Tiphia vernalis, the most valuable imported parasite of the same grub, has been shown by further surveys to be generally distributed and well established over at least 10,000 square miles for some distance beyond original points of colonization in Delaware, Maryland, and Pennsylvania northward into New York and Connecticut. Experimental colony units of 100 females each were furnished to West Virginia officials for release at 15 approved sites in that State, 8 in 1952 and 7 in 1953, and 2 similar units were furnished to Vermont officials for release in 1953. Bureau personnel also released two experimental colonies at an isolated infestation in Pennsylvania in 1952.

Four experimental colonies of *Centeter cinerea*, an imported parasite of the adult Japanese beetle, were released during 1952, one colony each in Massachusetts and West Virginia, and two colonies in New Jersey. About 1,700 puparia were collected in the field in New Jersey and stored at the Moorestown, N. J., laboratory, to provide adult flies for further colonization in 1953.

This phase of the work was placed in an inactive status at the end of the fiscal year.

Diseases of the Japanese Beetle

Some species of nematodes pathogenic to the Japanese beetle have been found to be pathogenic to the European chafer. It was also found that bacteria associated with the pathogenic nematodes produced antibiotic substances that could be demonstrated in cultures or in tissues of larvae infected with these bacteria or with the nematodes.

With one nematode species the pigment produced by the bacterium had antibiotic properties. Methods for extracting and purifying it were studied. A median infective dose of *Coxiella popilliae*, n. sp., a rickettsia causing blue disease of Japanese beetle larvae, was found to be less than 7 cells per grub. Calculations made from the results of dosage-infection studies indicated that the doubling time of the organism *in vivo* is about 9 hours. It was also found that development of disease in experimentally infected larvae could be prevented by the injection of streptomycin or sulfadiazine but not by penicillin or aureomycin.

An improved technique has also been developed for producing milky disease spores in mass quantities. By moistening soil-seed mixtures with formaldehyde the damping-off of the sprouted seed, used as food by the larvae in the process of producing the spores, can be prevented or retarded. Optimum effects were obtained with 100 ml. of 0.04-percent formaldehyde per kilogram of air-dry soil. No aeration of the treated soil was required and the soil treatment did not interfere with the infection of larvae or development of the milky disease organism. Where severe damping-off was encountered, the formaldehyde treatment increased spore yields by as much as 100 percent. Higher concentrations of formaldehyde markedly retarded germination of the seed and lower concentrations were less effective in preventing damping-off.

Injection Treatment for Balled Nursery Stock Promising

Preliminary tests have been carried on to develop an injection method of eliminating Japanese beetle grubs from balled nursery stock to permit movement to uninfested parts of the country. In these experiments, carried on at Moorestown, N. J., ethylene dibromide injected at the rate of 0.4 gram per square foot of the upper surface of the balls was effective in killing third-instar Japanese beetle grubs at temperatures from 40° to 70° F. in soil balls from 6 to 16 inches in diameter. An injection device has been developed for this work. Only 2 out of 48 varieties of plants have thus far shown injury from the treatment.

Japanese Beetle Regulatory Activities

In cooperation with the States concerned, trap-scouting was done during 1952 in every State outside the Japanese beetle-quarantined area except Idaho, Nevada, and North Dakota. Collections were made in 82 nonregulated localities in six quarantined States. In addition, beetles were collected at 24 locations in 5 States bordering the quarantined area, as well as at 5 places in Illinois and 1 in Missouri. Solitary hitchhiking beetles were trapped at the following airfields: Kelly Field, San Antonio, Tex.; Maxwell Field, Montgomery, Ala.; and Drew Field, Tampa, Fla. Rescouting of Kelly, Maxwell, and Drew Fields in June 1953 gave negative results.

During the summer of 1952, 12,000 airplane flights from 69 infested military and commercial airfields in 10 States and the District of Columbia were treated with aerosols previous to departure for destinations in the nonregulated area. In addition, 2,400 residual DDT

treatments were applied to planes. Traps and foliage treatments were used to reduce beetle infestations at many infested airfields from which there was outgoing traffic to noninfested areas. Approximately 2 million beetles were collected in these traps. Cooperating military and commercial airline employees removed large but unrecorded numbers of beetles from clothing and hand baggage of passengers entering planes.

Cooperative experiments to kill beetles in airplanes were continued. These showed that a commercially available low-pressure throw-away dispenser containing standard insecticide aerosol G–651 or military stock aerosol is effective against the beetle.

In cooperation with State pest-control agencies, soil and foliage treatments to control isolated beetle infestations were applied in 93 localities in 11 States during 1952. In these treatments 64,000 gallons of DDT foliage spray and 165 tons of soil insecticides, mostly DDT, were used. Cooperating States and local interests furnished most of the material and labor for these treatments. The Bureau's contributions were principally technical assistance and special equipment.

Cooperative control treatments were applied during June 1953 in East St. Louis, Ill.; Covington, Russell, and Louisville, Ky.; Atlanta and Dahlonega, Ga.; and in 16 Ohio localities.

The use of soil insecticides applied in powder form with low-cost applicators was recommended by the Bureau and accepted by some State cooperatives with a consequent saving in labor costs. This permitted more extensive and timely treatments. This method was used in Louisville, Ky., where 435 acres were surface treated with DDT.

A new nursery treatment using a mixture of ethylene dibromide and chlordane was authorized on June 15, 1953, for use on bare-rooted plants. This provides for immediate certification of treated plants without a holding period subsequent to treatment.

Spot checks during April and May 1953 made at State highway-patrol weighing stations showed considerable nursery stock moving via motor truck westward from the regulated areas. While most of the stock originated in Ohio and Pennsylvania, some of it came from nurseries in New Jersey, Connecticut, West Virginia, New York, and Rhode Island. All truckers had proper quarantine certification.

Seasonal-certification requirements for fruits and vegetables moving via refrigerator car or ventilated motor truck were instituted on June 18, 1953.

Quarantine certification services involved the certification of 172 million plants, 30,000 packages of fruits and vegetables, and 1,000 tons of soil. These were certified for 1,930 commercial establishments and 680 individual shippers in the regulated area. Articles certified had an estimated value of $13 million.

Since many nursery establishments in eastern North Carolina are now affected by both the Japanese beetle and white-fringed beetle quarantine, a joint certificate covering both quarantines was prepared and issued to eligible nurseries. A similar joint Japanese beetle and gypsy moth certificate has been in use for many years in the New England States.

GYPSY MOTH CONTROL AND CERTIFICATION ACTIVITIES

In May and June 1953 approximately 180,000 acres infested with the gypsy moth in Connecticut, Maine, Massachusetts, New York, Pennsylvania, and Vermont were sprayed by aircraft, and about 6,970 acres by mist blowers. The work was in cooperation with the infested States. A small, isolated infestation discovered in Milford Township, Bucks County, Pa., in the fall of 1952 has apparently been exterminated as a result of spraying with DDT in May 1953. No other infestation is known to exist in Pennsylvania.

Surveys conducted during the fiscal year involved more than 841,000 acres. Most of the scouting was done in the vicinity of trap sites at which male moths were captured during the summer of 1952. There were 1,176 infestations located as a result of this survey.

Observations during the 1953 larval period showed a marked increase in acreage of woodlands defoliated by the moth. Thousands of acres have been defoliated in western New England in the Connecticut River Valley and adjacent areas from the Massachusetts State line to a point north of White River Junction, Vt.; in isolated areas of eastern Massachusetts; in the Lake Winnepesaukee section of New Hampshire; and in the Lake Sebago region and costal sections of Maine, including the Penobscot and Kennebec River Valleys. There appears to be heavy egg deposition in many locations adjacent to the defoliated areas.

An appraisal of the gypsy moth problem was made during the summer and fall months of 1952 in cooperation with the United States Forest Service and collaborating State plant-pest officials. These studies clearly indicated an appreciable increase in gypsy moth abundance throughout the untreated infested area, and an extensive tree mortality and retardation of growth in areas defoliated by the gypsy moth on one or more occasions. A survey conducted throughout the Eastern States revealed an estimated 100 million acres of oak woodland south and west of the regulated area which were classified as being highly susceptible to severe damage should the gypsy moth become established there.

Experimental trap lines, used to study bait effectiveness and improvement in its attractant efficiency, were continued during the summer of 1952. It was found that the bait strength of the standard field trap could probably be safely reduced from 15 to 12 female abdominal tips, should this become necessary to conserve attractant material. Other results proved that hydrogenated sex attractant material showed no sign of deterioration after 5 years' storage, that materials obtained from laboratory-reared moths proved highly attractive to male moths, and that the paper-cone trap now used in field surveys is the most efficient of many variations tested.

Some investigation and some experimental work is being done by lumber dealers in the use of chemical weed-killers to keep storage areas free of weeds. Weed-free areas facilitate the drying of lumber and decrease the likelihood of female moths depositing egg clusters on lumber in storage.

Gypsy moth inspection certification activities were conducted within the 47,501 square miles of regulated area. This includes all of Massachusetts and Rhode Island, parts of the other New England States, and eastern New York. Some cooperative infestation surveys as well as regulatory work involving Canadian shipments were performed in sections adjacent to the regulated areas.

Due to the buildup in gypsy moth infestation in many sections of New England, inspections revealed a considerable increase in the number of infested shipments of regulated articles. From January 1 to June 30, 1953, a total of 49 shipments offered for inspection and certification were found infested with the gypsy moth, compared to 23 shipments during a similar period in 1952.

Amendments to the gypsy moth quarantine and regulations were made effective August 9, 1952, to conform to a comprehensive survey and review of current conditions of infestation and hazard of spread. Twenty-one additional towns in Litchfield and New Haven Counties, Conn., were placed under regulation.

More than 300 producers and operators were permitted to ship under provisional certification after production sites, processing, handling, and storage of products were maintained in a manner that would preclude carrying infestations to outlying areas. Seven hundred growing sites totalling more than 50,000 acres were scouted to determine presence or absence of infestation and to establish certification eligibility of products growing or produced at the sites.

The value of all products certified for movement from the regulated area during 1952 was estimated at $\$24\frac{3}{4}$ million. Approximately 2,000 commercial companies and 800 individuals requested regulatory services requiring a total of more than 17,000 service calls by inspectors.

Inspectors on highways during the peak of the 1952 shipping season checked approximately 1,600 vehicles. Of these, 945 were transporting properly certified regulated products, but 51 contained noncertified products moving in violation of the quarantine.

WHITE-FRINGED BEETLE ACTIVITIES

Cotton Sprays Also Provide Good White-Fringed Beetle Control

Foliage sprays of approximately 10 pounds of toxaphene per acre for the control of cotton insects during one season has provided good control of white-fringed beetle larvae in the soil for the following two years. Effectiveness decreased during the third year.

Application of 2.27 pounds of dieldrin per acre as foliage sprays on noncultivated land during two adult seasons gave fair control of white-fringed beetle larvae in the soil each year. Dieldrin was more effective as a foliage spray on noncultivated land than several other insecticides.

DDT-Fertilizer Mix Tested for White-Fringed Beetle Control

A DDT-fertilizer mixture prepared by a fertilizer manufacturer and sold in Alabama and Florida in 1951 was found effective against

newly hatched white-fringed beetle larvae 6 months after being mixed. DDT mixed with three commercial fertilizers and stored for 5 months lost none of its effectiveness when used against newly hatched larvae.

In other experiments, DDT mixed in the soil at 10 pounds per acre gave good control of newly hatched larvae for 7 years after application. Twenty-five pounds per acre gave complete mortality for 5 years, and 50 and 100 pounds per acre gave similar protection in all 7 years since application.

Other materials which continue to show promise as soil insecticides capable of destroying the larvae are aldrin, chlordane, dieldrin, heptachlor, and toxaphene.

On farmland, DDT applied in the drill row at planting time for 3 consecutive years, in 1946, 1947, and 1948, at 2.5 or 5 pounds per acre has given good control of the white-fringed beetle each year through 1952.

One application of DDT applied broadcast at the rate of 10 pounds per acre and disked into the upper 3 or 4 inches of soil in 1947 and 1948 has given good control of the beetle each year through 1952.

Regulatory Activities

Since 1946 more than 52,000 acres of agricultural land have been soil-treated with 10 pounds of DDT per acre for white-fringed beetle control. Farmers and growers have now assumed this phase of control work. Since 1950 farmers have applied DDT-fertilizer mixtures to an additional 10,000 acres of farmland. Since 1948 about 3,100 acres of nursery land have been soil-treated with 50 pounds of DDT per acre. Responsibility for this procedure, which allows certification of nursery plants for movement without further treatment, has also been assumed entirely by the growers. During 1951 and 1952, some 6,000 acres of industrial and other noncultivated land, on which DDT could not be cultivated into the soil, received a 25-pound per acre surface application.

During the year expenditures by the States, counties, municipalities, industrial concerns, growers, and others exceeded the expenditure by the Bureau. Insecticides were furnished and applied in the greater part by the individual concerned. Some insecticides were supplied by the States.

By the end of 1952 beetles occurred in 152 counties in 8 States. During 1952 infestations were found for the first time in the following nine additional counties: Elmore County, Ala.; Hancock County, Ga.; St. Charles Parish, La.; Copiah, Lawrence, Lincoln, and Wayne Counties, Miss.; Scotland County, N. C., and Horry County, S. C. No specimens have been found for three or more years in Clay, Clayton, Effingham, Habersham, Muscogee, Spalding, and Troup Counties, Ga.; Montgomery County, Miss.; Bladen County, N. C., and Fairfield County, S. C. These 10 counties therefore were removed from the infested list, with the result that a total of 142 counties are recognized as having active infestations. In these 142

counties 376,755 acres are classified as infested. No specimens could be recovered during 1952 on approximately 24 percent of the acreage classified as infested; light populations were present on 48 percent of the infested acreage; moderate populations on 24 percent; heavy populations on only 4 percent.

Surveys were conducted in noninfested States adjoining infested ones, and in States which may have been exposed to infestation from domestic or South American sources. The beetle has not been reported in a new State since 1948 even though extensive surveys have been made.

AIRCRAFT AND SPECIAL EQUIPMENT CENTER

During the year the Aircraft and Special Equipment Center at Oklahoma City, Okla., provided research and control units of the Department with technical assistance in the specialized field of agricultural aviation. These services included (1) technical advice in the preparation of bid specifications for contract aircraft services; (2) inspection of contractors' equipment and examination of pilots' qualifications prior to bid acceptance to determine whether bid specifications had been met; (3) inspection of equipment and personnel during operations to insure compliance with contract requirements, and (4) experimental and operational baiting and spraying.

Technical assistance in the supervision of the Bureau's control operations was extended to include those against grasshoppers, Mormon crickets, and gypsy moths, and areas not under contract were treated by Bureau aircraft. Similar aid was given to the Forest Service in connection with spruce budworm operations.

The Center assisted the Division of Cereal and Forage Insect Investigations by making experimental applications for the control of grasshoppers and Mormon crickets; it provided equipment and personnel for experimental applications of granulated and liquid 2,4-D for the control of white pine blister rust and of granulated DDT and dieldrin to brush and woodland areas for white-fringed beetle control; it assisted the Division of Insects Affecting Man and Animals in developing methods of dispersing screwworm pupae from airplanes for use in biological studies; and it provided aircraft and personnel for survey work on the gypsy moth and other forest insects.

The Center participated in many conferences and pest-control schools held to acquaint operators with the latest information concerning the aircraft application of insecticides. The informational program included many demonstrations of Bureau equipment. In addition to maintaining Bureau aircraft in first-class operating condition, the Center made many improvements in this equipment. It cooperated with the Civil Aeronautics Administration in developing a high-lift wing for use on Stearman aircraft. This development encouraged several companies to design and sell new wings of similar configuration.

IMPROVEMENTS IN ADMINISTRATIVE PROCEDURE

An overall system was established to integrate budget and accounting work in a manner that records financial information and reports the status of funds with a minimum of effort and expense. This included a revised system of providing field station leaders with a day-to-day record of amounts available to them for their various activities. Training sessions were held to acquaint operating personnel with features of the system. The method of recording obligations was also changed to eliminate unnecessary work on the part of field stations.

Classification audits were made of 518 Bureau positions during the year and an additional 1,262 position descriptions were reviewed.

Composite viewpoints of regional directors, and division and project leaders were obtained on the major phases that could be most advantageously developed by training and welfare personnel.

As part of the Bureau's incentive-awards program, three cash awards were granted, 10 one-step increases in salary given, and five letters of commendation written, in addition to the distinguished service and superior service awards reported elsewhere.

Numerical and functional files have been set up to maintain a control over issuance and use of Bureau forms.

Inquiries were made in the field to determine the present status of cooperation between Bureau field stations and State, county, and other interests. Where feasible, suggestions were made for improving these cooperative relations.

A uniform filing system has been installed in practically all Bureau offices. Obsolete records occupying 3,228 cubic feet were disposed of during the fiscal year. In the last 5 years, obsolete records occupying the equivalent of 7,088 file drawers were destroyed.

Property valued at more than $500,000 was reassigned between Bureau activities to obtain better utilization of equipment.

Another improvement was a system installed to facilitate reconciliation of motor vehicle records and reports. Regional offices report to the Washington headquarters changes in the status of each vehicle. Reconciliation of reports and records was performed at a saving of 6 weeks' time for one employee. This system focuses attention on vehicles that should be replaced and those that are available for transfer to activities where they can be better utilized. During the year, there was a reduction of 93 in the Bureau's inventory of motor vehicles.

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Assistant Chief (Insecticides and Chemicals)	H. L. HALLER.
Assistant Chief (Regulatory)	VACANCY.
Staff Assistant (Regulatory)	R. W. SHERMAN.
Assistant Chief (Administration)	R. A. SHEALS.[2]
Deputy Assistant Chief (Administration)	H. G. HERRELL.
Division of Administrative Services	L. K. WRIGHT.
Division of Accounting and Auditing	A. F. HEALY.
Division of Budget and Administrative Management	H. G. HERRELL.[3]
Division of Personnel Management	W. F. LEFFLER.
Division of Bee Culture and Biological Control	J. I. HAMBLETON.
Division of Cereal and Forage Insect Investigations	W. A. BAKER.
Division of Forest Insect Investigations	J. A. BEAL.
Division of Fruit Insect Investigations	B. A. PORTER.
Division of Information	D. G. HALL.
Division of Insect Detection and Identification	C. F. W. MUESEBECK.
Division of Insecticide Investigations	R. C. ROARK.
Division of Insects Affecting Cotton and Other Fiber Plants.	K. P. EWING.
Division of Insects Affecting Man and Animals	E. F. KNIPLING.
Division of Plant Quarantines	E. R. SASSCER.
Division of Stored Product Insect Investigations	RANDALL LATTA.
Division of Truck Crop and Garden Insect Investigations	G. J. HAEUSSLER.
Aircraft and Special Equipment Center	KENNETH MESSENGER.
Director, Northeastern Region	R. G. RICHMOND.
Golden Nematode Control Project	J. F. SPEARS.
Gypsy and Brown-Tail Moth Control Project	J. M. CORLISS.
Japanese Beetle Control Project	WILLIAM MIDDLETON.
White Pine Blister Rust Control Project	E. C. FILLER.
Director, Southeastern Region	W. G. BRUCE.
Phony Peach and Peach Mosaic Control Project	A. E. CAVANAGH.
Sweetpotato Weevil Control Project	M. S. YEOMANS.
White-Fringed Beetle Control Project	R. A. ROBERTS.
Director, Southwestern Region	L. F. CURL.
Mexican Fruit Fly and Citrus Blackfly Control Project	N. O. BERRY.
Pink Bollworm Control Project	R. W. WHITE.
Wild Cotton Eradication Project	W. E. CONN.
Director, Western Region	W. V. BENEDICT.
Hall Scale Eradication Project	E. H. FOSEN.
White Pine Blister Rust Control Project	T. H. HARRIS.
White Pine Blister Rust Control Development and Improvement Project	H. R. OFFORD.
Director, North Central Region	H. L. SMITH.
Barberry Eradication Project	R. O. BULGER.
Grasshopper Control Project	J. R. DUTTON.
White Pine Blister Rust Control Project	H. N. PUTNAM.

[1] Resigned effective June 30, 1953.
[2] Retired effective June 30, 1953.
[3] Acting in charge.